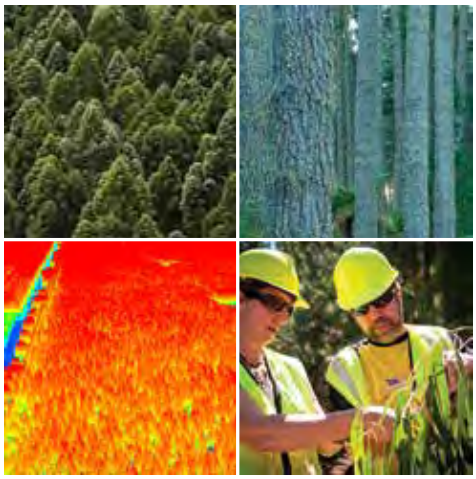
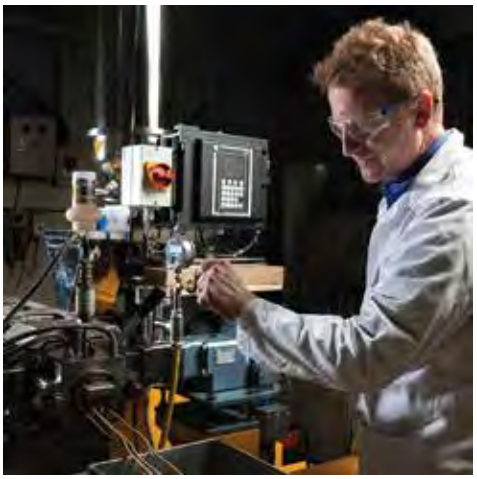
SCION
forests · products · innovation

Annual Report 2015
Highlights






SCION
forests · products · innovation

Industry focus

Added value

Regional development

Annual Report 2015
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.

Our Annual Report is also available in digital format at www.scionresearch.com/annualreports

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Contents

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.

Scion at a glance

$47.3m
Operating revenue
Last year: $48.1m

287
full-time equivalent staff

261	1	24	1
Rotorua	Wellington	Christchurch	Dunedin

126
published papers

- 53.57 annual weighted average H-index
- 7.66 citations per paper (rolling 10-year average)

Strong confidence in forestry's future

Tony Nowell CNZM, Chair *Dr Warren Parker, Chief Executive*

Chair and Chief Executive review

Scion has completed another busy, stimulating and challenging year pursuing its core purpose to provide the science that helps drive innovation and growth from New Zealand's forestry, wood product and wood-derived materials sectors. Our focus has been on increasing the contribution of plantation forests to national and regional economic development, driven by our vision of creating "Prosperity from trees" for New Zealand and New Zealanders.

Our work has had an increased emphasis on harnessing sector complementarity. Specific initiatives will assist the integration of forests with other land uses in order that more stringent environmental requirements are met, and more products are used in supply chains. This will benefit environmental and social outcomes, support regional job creation and help Māori achieve their aspirations.

We have carried out this work within dynamic industry, business, science and political environments, with intense review of our future funding streams and how our investment in publically funded science is made. This has involved significant work engaging with five National Science Challenges relevant to Scion's future, and towards year end, an extensive Four Year Rolling Review of Scion. Our resources were challenged, and we have been required to adapt, to change and to upskill accordingly, while also seeking to grow income from the private sector.

To address these changing dynamics and the opportunities they present, we added exciting new talents during the year to enhance our capabilities in value chain optimisation, market analysis, informatics and 'big data', human factors research (for improved health and safety in the forest industry), biopolymers, biotechnologies, biofibres and green (or 'clean') technologies.

At Scion, we have a strong confidence in forestry's future, supported by the re-elected government's ongoing commitment to achieving business growth agenda targets, with specific aims to lift GDP growth in under-performing regions that all have

large forestry sectors. Also, global trends are driving resource-efficient and renewable economic growth; and domestic imperatives are in force to improve freshwater quality, address climate change and enhance the built environment. These are opportunities for Scion to contribute to, and have further sharpened the focus of our research.

A record harvest of 30 million tonnes of logs in the past year, expected to reach 32-36 million tonnes per annum over the next decade, augurs well for the forestry sector and the positive economic impact it can make to New Zealand. However, with deforestation of some 100,000 hectares in recent years, the wood processing sector faces major concerns over the security of log supply from the late 2020s if planting levels of both harvested and new forests are not substantially increased.

Iwi aspirations to plant up to 1 million hectares of forests on under-utilised land, including indigenous and non-radiata pine exotic species, is an important opportunity for both reforestation and regional development that is being supported by our science.

With impending global shortages of the long fibre softwood used as an essential ingredient for packaging and lightweight material substitutes for fossil oil products, and with the new global impetus for addressing climate change by the setting of meaningful 2030 individual country commitments, we see New Zealand's radiata pine plantation forests facing a very positive future by providing excellent mitigation and value creation opportunities. Our science continues to make ground in international and domestic 'bio-economy' research and development opportunities, whether they be for packaging and coatings, lightweight wood-plastic composite components, industrial heating options or biofuels. Notably, our Woodforce technology for thermo-plastic wood composites is now undergoing industrial-scale commercial testing within the automotive and other sectors.

Weather events and heightened concerns about biosecurity risks over the past year have reinforced the forest owners' need to adapt their tree genetics, forest management and forest protection for more extreme weather and biosecurity incursions. Our science programmes strive to double forest productivity, reduce forest biosecurity, wind and fire risk, and secure licence to operate in areas such as new genetic technologies, alternatives to methyl bromide for log fumigation and steep land harvesting.

Demand for up to 30,000 new houses per year in New Zealand over the next decade, and an imperative to improve housing affordability through mechanisms like pre-fabrication, better standards and gains in supply chain efficiency, has increased our focus on the development of better building solutions and establishing closer links with BRANZ and the construction sector. We continue to develop our understanding of how the characteristics and structure of our timber can best contribute to stronger, more innovative and more cost-effective engineered wood products for structural solutions and modified wood products to replace tropical hardwoods.

Scion's technology focus is enabling productivity gains and essential improvements to worker health and safety across the forestry value chains. We are supporting the rapid uptake of 'smart connected products' for precision forestry, including the use of unmanned aerial vehicles with LiDAR capability, mobile tree scanners, robotics for mechanised pruning and harvesting and decision support tools for small forest owners. Also, our work with Solid Wood Innovation on log segregation technologies continues.

During the year we refined and reviewed Scion's values, consistent with our changed work environment, and our changing customer and stakeholder needs. Ingenuity, Collaboration, Excellence, and Manaakitanga express the refreshed approach of Scion to its work and purpose. We retained Scion's ACC tertiary Workplace Safety Management Practices accreditation.

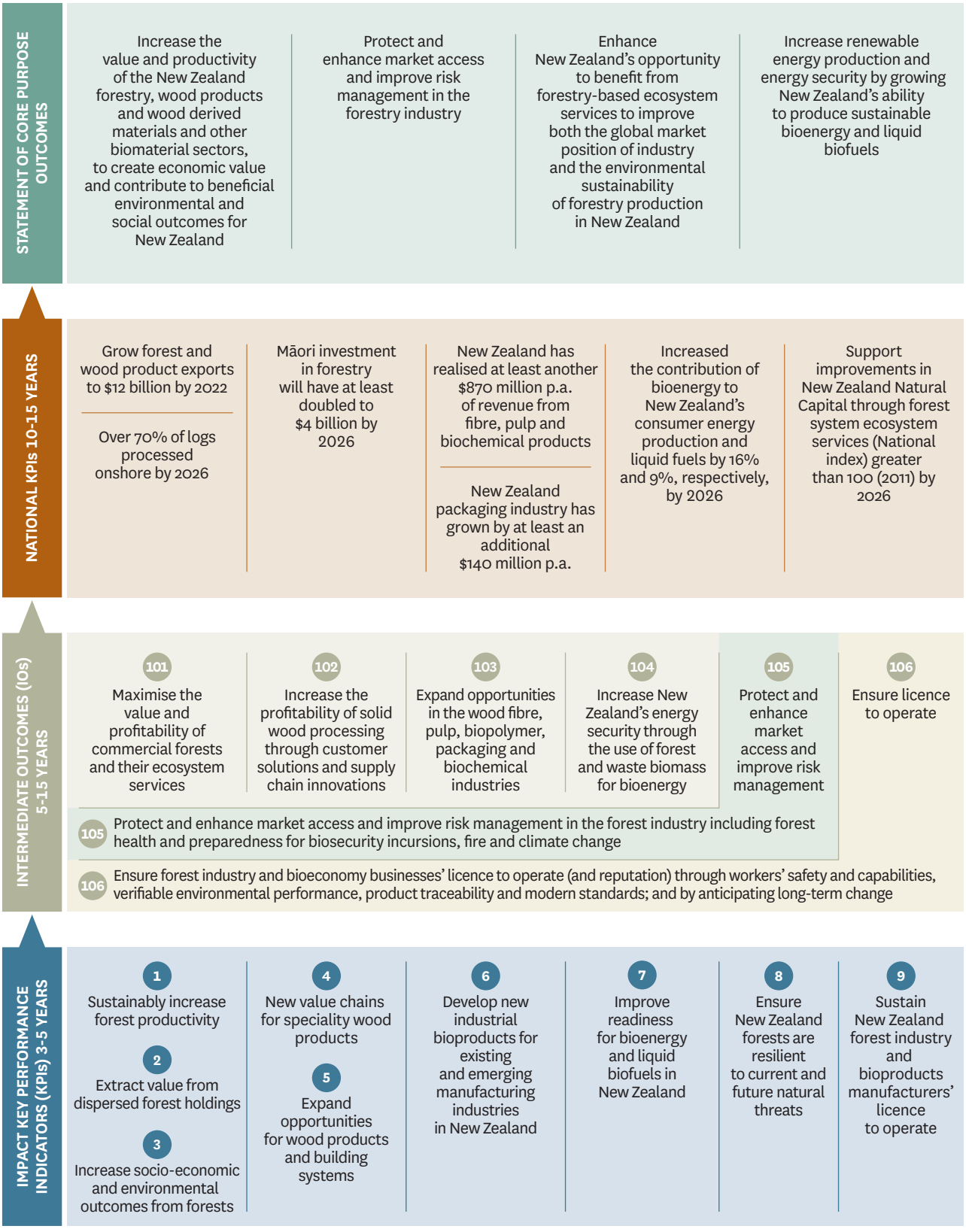
Revenue of $47.34 million was below budget of $49.12 million, reflecting both delayed and reduced public sector funding. However, EBIT of $3.27 million and NPAT of $2.43 million were above budget of $2.50 million and $1.77 million respectively, mainly reflecting timing related savings in personnel costs as staff capability was built in the new fields identified above. Return on equity was 7.3 per cent above budget of 5.6 per cent. Capital expenditure of $4.44 million, including $1.73 million carried forward from the prior year approvals, maintained our momentum in modernising and improving the safety of our facilities, plant and equipment, and in strengthening both campus and cyber security. The 10-year plan for the Rotorua campus was updated in preparation for a major refurbishment and consolidation of our wood engineering laboratories and pilot plant facilities over the next two years.

We thank Scion staff for their hard work and ingenuity; and our industry, iwi and policy stakeholders for their advice and support. Brian Rhoades completed his final year as a Scion Director - we thank him for his wisdom and wide-ranging input over the past six years. The remaining Directors will continue into the new financial year providing continuity through a period of substantial change in the New Zealand science sector.

Tony Nowell CNZM
Chair

Dr Warren Parker
Chief Executive

Our science plan



This plan (from our 2015-2020 Statement of Corporate Intent) shows how Scion's activities align to achieving the Statement of Core Purpose (National) Outcomes and the inter-dependency between National and Intermediate Outcomes and performance measures (National and Impact KPIs respectively).

Commercial forestry and ecosystem services

IO1 – Maximise the value and profitability of commercial forests and their ecosystem services

Impact KPI-1: Sustainably increase the productivity of New Zealand forests. By 2019, tools, novel forest management approaches and new plant material will be embedded into New Zealand's forests and forestry practices to support the industry's target to increase radiata pine Mean Annual Increment from an average of 20 m^3 ha^{-1} yr^{-1} to 35 m^3 ha^{-1} yr^{-1} and in a way that enhances the sustainability of forest growing in New Zealand.

LEADING INDICATORS

On-going: the Forestry Library, Permanent Sample Plots (National Forest Tree Database), and Tree Genetic Archives remain viable and provide valuable information about the national forestry position for New Zealand.

By **2016**, Scion will have quantified the gap between current productivity and potential productivity that could be achieved if key limiting factors could be overcome. This will be informing industry strategies to sustainably improve productivity, including breeding for growth and quality.

A phenotyping platform has been used to identify outstanding individual trees for at least one key trait with superior germplasm and is being deployed by **2016**.

By **2016**, at least two new biotech trees are evaluated for traits (e.g. productivity and herbicide resistance) and reported to stakeholders.

By **2018**, Scion will have developed a systems model of the current forest products value chain to determine where to intervene in order to maximise benefits from the existing forest resource. This will have created better connectivity between growers and processors, and better connectivity between small-scale forest growers.

2016 **2017** **2018**

PROGRESS

The process-based model CABALA now has parameters for radiata pine in New Zealand. The initial calibration/validation process for CABALA provided new insights into productivity limitations at case study sites and identified productivity levers to increase productivity. Factors limiting productivity included nitrogen availability and soil water holding capacity. Analysis of existing radiata trials revealed a real (not simulated) productivity gap for radiata pine that can be exploited. Development of a nationwide productivity map in 2015-16 is on track with the initial results to be presented to New Zealand Forest Owners Association in October 2015.

Early evidence for the phenotyping platform at industry scale, is promising. LiDAR may be used for inventory and/or understanding forest resource characteristics. A genetic trial is underway to match remotely sensed individual tree data with ground-based individual tree phenotyping data. First steps in developing the GCFF phenotyping platform were demonstrated at the GCFF annual conference in March 2015.

A contained field trial of biotech trees with modified lignin was established in March 2014. The modification will reduce the energy cost of processing for pulp or biofuels production.

Herbicide resistant plants underwent final growth measurements; this trial is due to end in 2015 in line with EPA's approval conditions.

Several value chain systems models are being assessed. Detailed processed based discrete event simulation tools have been developed to assist industry with logistics planning and capacity utilisation challenges. A more aggregated tool helps researchers to identify inconsistencies across the supply chain.

Data from the Permanent Sample Plots supported at least five publications and were used to identify opportunities at specific forests to change silvicultural regimen to maximise productivity.

Boosting forestry productivity and economics

Growing Confidence in Forestry's Future (GCFF) is a joint research programme between industry, Scion and MBIE that aims to boost the productivity and economics of forestry, and provide a stable supply of quality timber for wood processors. It also focuses on ensuring that future intensification is environmentally and socially acceptable.

Our GCFF research team has already made a number of important achievements since the programme commenced in October 2013.

By more fully utilising site potential, scientists have calculated that productivity can be increased by 5-8 $m^3\ ha^{-1}\ yr^{-1}$. In today's log market, this would yield a further $13,000 per hectare (gross) over a 30-year rotation. Scientists are using process-based models to estimate the level of productivity that is possible, which has highlighted the impact of soil water holding capacity.

In today's log market, this would yield a further $13,000 per hectare (gross) over a 30-year rotation.

"To complement this modelling work, we are establishing the first of our accelerator trials this winter to provide data on the levels of productivity that are possible," says Science Leader Dr Peter Clinton. "These trials contain different genotypes and site modification treatments aimed at improving productivity.

"We will also use these trials to study the effects of increased productivity on wood formation. As part of this work, our scientists have developed a new micro-coring technique that makes it possible to obtain data on wood properties from an earlier stage than is currently possible."

The GCFF programme is building on the legacy of trials that were established more than 25 years ago to study the effects of stand density and seedlot on growth and wood properties. Results from these trials are guiding forest managers in developing silvicultural regimes for the next rotation. Data from two of the Long-Term Site Productivity trials have provided new insights into the productivity and sustainability of planted forests over multiple rotations. These data are being fed into the nutrient balance model (NuBalM) to enable forest managers to take a more targeted approach to forest nutrition.

"The programme has helped us gain a better understanding about the role of soil micro-organisms on productivity," says Peter. "The development of new assays for profiling microbial communities in soils enables us to analyse the use of nutrients on seedling performance. We are currently planting new trials to examine the effects of different treatments on microbial communities and ultimately, tree growth and health.

"We've also made huge advances in using both terrestrial and airborne LiDAR, as well as multispectral satellite imagery, to obtain productivity metrics and information on tree characteristics. At the same time, we're exploring unmanned aerial vehicles as possible platforms for these remote sensing technologies."

By **2019**, at least two major forest growers have changed their management practices and are applying new treatments designed to increase productivity of mid-rotation stands.

2019

Industry cluster group meetings revealed gaps and opportunities for new treatments. Workshops with a soils focus were put in place to address this gap and will be completed in September 2015.

Trials were planned to screen a range of treatments to improve forest nutrition, stimulate site processes, boost crop health and reduce site losses using new techniques; trials will be implemented from September 2015 focusing on assessments of risk and cost effectiveness.

Further advancements have also been made to the Forest Investment Finder spatial economic model to include different forest ecosystem services and timber values to support decisions around integrated land management. This work has contributed to discussions at the national and regional levels around land-use policy.

Working with industry to achieve our goals

The GCFF programme relies on a strong level of engagement between scientists and industry. Four innovation clusters have been formed as a means of creating greater impact from our science and to provide a forum for discussion. Our scientists regularly meet with an industry technical committee to ensure that the work is achieving the desired impact.

As a result, forest growers now place a greater focus on productivity as a management goal and recognise the importance of site occupancy as a driver of productivity. Most companies refer to stand density index when evaluating silvicultural regimes, and have a far greater understanding of how these regimes, site and genetics affect wood quality.

LiDAR and other remote sensing technologies are increasingly becoming part of mainstream forest management with forest managers seeing new uses for these technologies.

Furthermore, there is a greater evidence base that can be used in debates on environmental issues, such as land-use, water quality and biodiversity protection. Research has increased awareness by forest owners and government policy makers of the value of forest ecosystem services, such as flood and erosion protection, and recreation.

Landcare Research, Waiariki Institute of Technology, University of Auckland, Oregon State University (US), US Forest Service, University of Canterbury, CSIRO (Australia)

MBIE, FGLT

http://gcff.nz/publications
www.scionresearch.com/ar15boostingproductivity

Breeding technologies for the future

Scion's Biotransformation Team has been working with the University of Wisconsin-Madison to make radiata pine and other softwoods easier to process into such things as pulp and biofuel.

Easier to process softwood offers both economic and environmental benefits. Needing less energy, the pre-treatment will be faster, more efficient and less wasteful, yielding improved feedstock for pulp, paper and biofuel industries. Led by Dr Armin Wagner, the team published its work in the *Proceedings of the National Academy of Sciences* proving the concept that it is possible to change the makeup of lignin polymers in softwoods.

This is just one example of plant biotechnology being investigated by Scion in conjunction with other international and national research institutes.

Scion is the leading centre for pine biotechnology globally. For over 10 years we have been showcasing, to the forestry industry and other stakeholders, transgenic radiata pines that demonstrate measurable phenotypic improvements developed through genetic engineering.

Our research provides scientific and commercial evidence to industry, government, Māori and other stakeholders in readiness for the necessary regulatory changes that will give industry the freedom to adopt technologies already deployed by international competitors, and to meet climate change challenges.

Metabolic engineering allows a single, clearly identified desirable trait to be introduced where it is not normally present. Scion has demonstrated genetically improved radiata pine for a number of traits. Most recently, we have streamlined the production of improved trees and developed an efficient field trial testing platform. This has enhanced our ability to showcase proof-of-concept experiments with high scientific rigour.

A field trial of the lignin-modified radiata pines has been planted to demonstrate easier processing and pulp-ability.

Also, some 3000 plants will be planted in Scion field trials in 2015-16, with traits including productivity and altered biochemical composition.

Business cases have been developed for a number of these traits. For example, infertile Douglas-fir to support the profitability of growing a species where the cost of wilding control inhibits planting. Also, the adoption of herbicide tolerant trees that will complement the use of environmentally sustainable and cost-effective herbicides.

Although several existing genetic engineering and emerging biotechnologies are ready to be deployed, the regulatory routes to release these biotechnologies are not yet available. Scion is continuing engagement with regulatory authorities, Crown entities and other stakeholders to define clear pathways for safe and environmentally responsible deployment of biotechnologies in the future, and the benefits they will offer New Zealand.

University of Wisconsin-Madison (US), University of British Columbia (Canada), University of Aachen (Germany), Plant & Food Research, University of Waikato

Scion Core, two post-doctoral researchers

www.pnas.org/content/112/19/6218.full.pdf
www.scionresearch.com/ar15breedingtechnologies

The value of long term trials in demonstrating genetic gain

Analysis of an extensive dataset from a series of large-plot radiata pine trials, indicate that genetically improved tree stocks have increased the present value of the national radiata pine estate by an estimated $3.5 billion.

A further switch to highly improved stocks is underway, with an estimated value uplift to the industry of $8.5 billion compared to using unimproved material.

Scion established the first genetic gain trials in 1978. These trials have been monitored for over 30 years and represent one of the most extensive datasets of its kind internationally. Additional data has recently been included from a major forest grower.

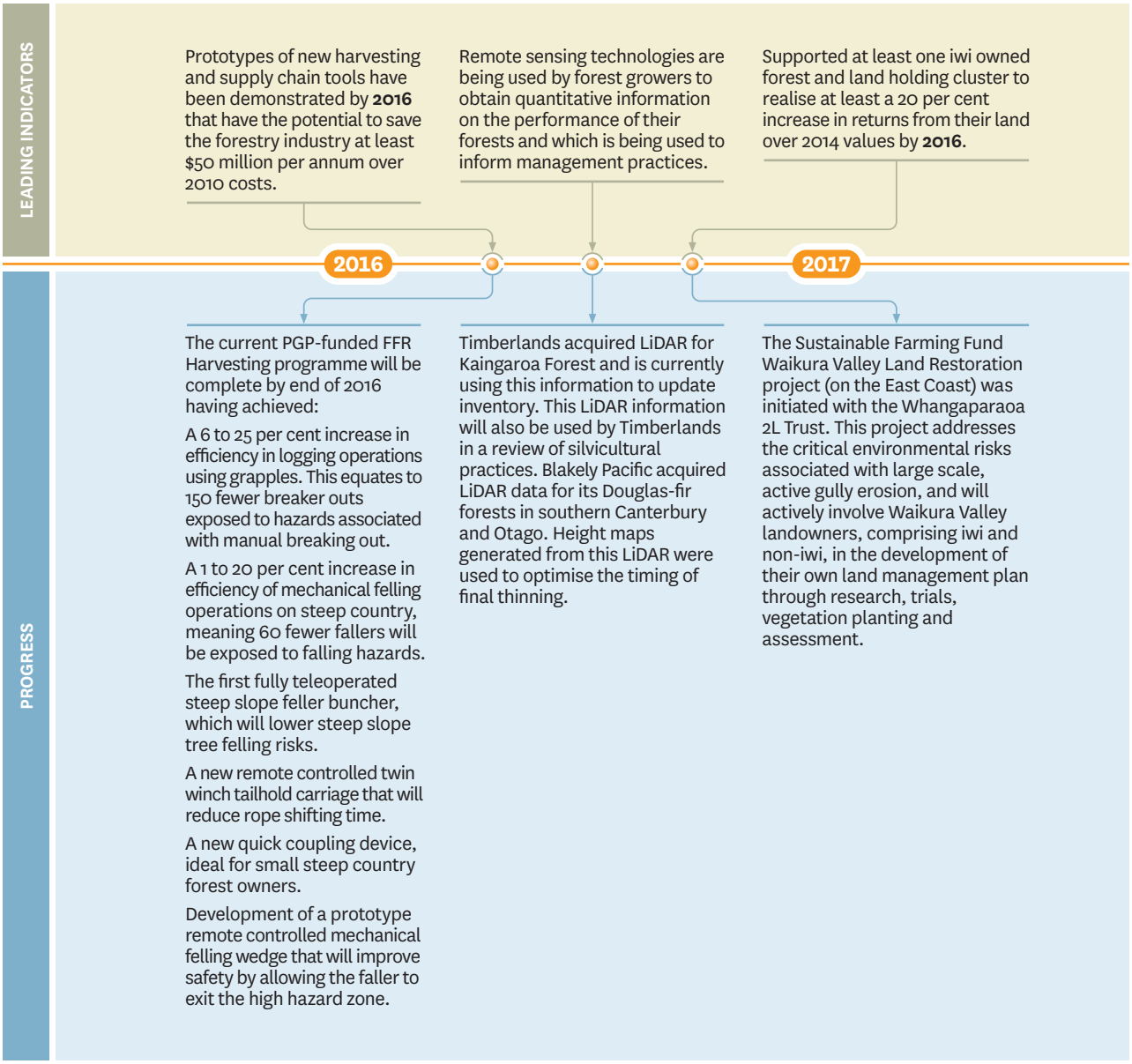
Our analysis has shown a strong relationship between the level of genetic improvement and the increased volume that is grown, and that the magnitude of realised genetic gain increases over the life of the plantation.

Quantifying realised genetic gain is a major focus of the Radiata Pine Breeding Company.

“Although genetic-based gain in tree breeding can readily be demonstrated in controlled breeding trials, it is very difficult to show the benefit of improved genetics in long-term commercial forestry operations,” says John Butcher, Chief Executive of the Radiata Pine Breeding Company. “This work makes a major contribution to providing credible scientific evidence that links genetic improvement to productive gains in volume and density in 30 year stands. This is the evidence that gives our shareholders, representing all major national forestry companies, the confidence to invest in genetic improvement”.

www.scionresearch.com/ar15longtermtrials

Impact KPI-2: Extract value from forests and dispersed forest holdings. By 2019, tools developed by Scion and its partners will be used by New Zealand forest growers and harvesting companies to reduce harvesting costs, improve safety of tree extraction and improve supply chain logistics, leading to growth in regional tree planting.



No worker on the slope, no hand on the chainsaw

New harvesting technologies developed by Future Forests Research Ltd (FFR), as part of its Steepland Harvesting Primary Growth Partnership programme with the Ministry for Primary Industries, are paving the way for a step change in steep slope harvesting operations.

The Steepland Harvesting programme was initiated in 2010 with Scion engaged to carry out harvesting research projects. Scion's research team, led by Spencer Hill and Dr Paul Milliken, is looking at ways to improve the productivity and safety of steep slope harvesting.

Future Forests Research data indicate that approximately 44 per cent of the current harvested area in New Zealand is from steep terrain (slopes over 20 degrees). This is forecast to rise to 53 per cent by 2016 and to over 60 per cent by 2025. Felling and breaking out are the highest risk jobs in such conditions with workers constantly exposed to falling trees, swinging stems and dislodged debris. In 2013, eight of the 10 loggers who lost their lives that year were involved in either breaking out or tree felling.

The introduction of winch-assisted mechanical felling machines, matched with grapple extraction, has undoubtedly improved safety. Since the programme began, the proportion of operations mechanically felling on steep country has increased from less than one per cent to 16 per cent, which means 50 fewer tree fallers are exposed to felling hazards. However, while the machine operators are protected by a reinforced cab, they

Photo: FPNZ Ltd.

are now operating on slopes often over 50 degrees and as such, there is still a risk of machine rollover and harm to the operator.

The combination of steep country felling and bunching including FFR's remote controlled technology, matched with grapple yarders, could save the industry $10 million in harvesting costs by the end of this year, and this is just the beginning.

One objective of the Steepland Harvesting Programme was to introduce remote control and then full teleoperation of a steep slope felling machine. In June this year, remote control with video feedback was successfully installed into a feller buncher and field tested by harvesting contractor Ross Wood, of Wood Contracting Nelson 2014 Ltd.

"At the start, I was a bit dubious about the advantage of remote controlling my machine," says Ross. "As a result of the work done by Paul and Spencer and the team, my mind has been opened to a whole raft of opportunities.

"There is no doubt in my mind this will improve safety of steep slope felling operations more than what we have already achieved with our winch-assist system, and I see it really expanding the pool of potential employees for logging."

The next step will be installing full teleoperation to Ross Wood's feller buncher, allowing his operator to successfully operate the machine outside the line of sight. The first fully teleoperated unit is expected to be completed and commercially available by June 2016. While the technology itself is unlikely to lower felling costs, it will lower the risk of steep slope tree felling even further and eventually remove the need for feller bunchers to be built with cabs.

The combination of steep country felling and bunching including FFR's remote controlled technology, matched with grapple yarders, could save the industry $10 million in harvesting costs by the end of this year, and this is just the beginning.

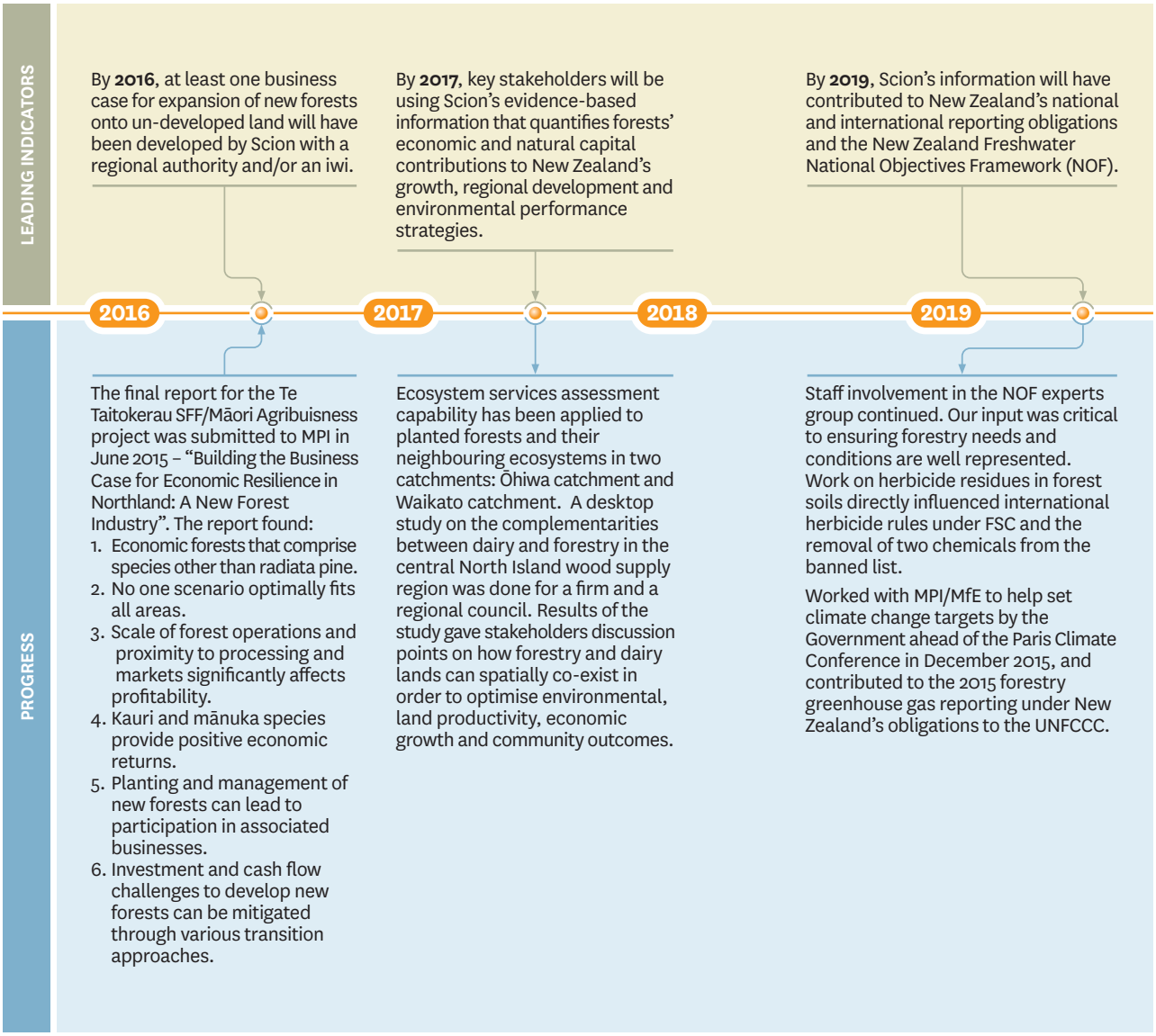
The remote controlled feller buncher has received excellent feedback from FFR's Technical Steering Team and has been presented to a supportive audience at the HarvestTECH 2015 conference.

Machine manufacturers, Wood Contracting Nelson 2014 Ltd, industry contractors

FFR, PGP

www.scionresearch.com/ar15ontheslope

Impact KPI-3: Quantify the role of forests in increasing economic, environmental and social outcomes for New Zealand. By 2019, Scion and its partners will have compellingly demonstrated to key stakeholders (e.g. Māori, regional councils, policy makers) the role of forests in creating resilient landscapes through forest contributions to regional economies and provision of ecosystem services.



Exotic forestry has positive ecosystem service value

In 2014, Scion's Economics, Ecosystems and Climate Team was contracted by the Bay of Plenty Regional Council to evaluate the ecosystem services relevant to different land uses in the Ōhiwa catchment.

Identifying, and attributing a value to, the key ecosystem services provided by each land use will provide the council with a framework for land management that will see the potential of each service realised.

"We define ecosystem services as the flow of benefits people gain from ecosystems, such as food, fibre, carbon sequestration, recreation and avoided erosion," says resource economist Dr Richard Yao.

"Food and fibre have traditionally been considered more important than the other groups because of their monetary value. Services such as recreational walking and avoided sedimentation in waterways, are already recognised in policy but have non-monetary values, which make them less clearly understood.

"The development of non-monetary valuation techniques now makes it possible to estimate the value of these

Adopting a more environmentally friendly technology or farm practice that reduces nutrient leaching in the waterways could double the overall ecosystem services value in the catchment.

services and include them in land management discussions, alongside those services with monetary values. This allows better policy to be made."

The team identified seven major land uses in the catchment, both productive (dry stock, exotic forests, dairy and horticulture) and natural (indigenous forest, scrub, and wetlands and mangroves). Researchers also applied Scion's Forest Investment Finder economic model to analyse the value of key ecosystem services such as timber, carbon and avoided sedimentation.

Of the productive land uses, horticulture and dairy were found to provide the highest monetary values (i.e. profit), with exotic forestry and dry stock the lowest. The monetary value of horticulture was over five times higher than dairy, and 18 times higher than exotic forestry.

However, when services with non-monetary values were included, exotic forestry was found to be the only productive land use with a positive ecosystem service value. Among natural land uses, wetlands provided the highest value per hectare, followed by indigenous forest and scrub.

The research team used several scenarios to demonstrate the potential profitability of various productive land uses, and the environmental and social values from both productive and conservation land. This exercise illustrated ways in which the overall economic, environmental and social values of the catchment could be improved.

"Our results suggest that shifting to a more sustainable productive land use can raise the overall ecosystem services value in the catchment," says Richard. "For example, converting 320 hectares of dry stock to exotic forestry could provide a net gain of $8,906 per hectare per year, and increase the ecosystem services value in the catchment by $2.8 million. Adopting a more environmentally friendly technology or farm practice that reduces nutrient leaching in the waterways could double the overall ecosystem services value in the catchment.

"The monetary values we are reporting here are indicative, not absolute dollar values, but provide a good starting point from which council can begin comprehensive land management planning for the Ōhiwa catchment that will deliver beneficial ecosystem services, particularly around water management. Good planning will sustain and enhance the provision of those services for economic prosperity and improved human well-being."

The final report was completed in October 2014 and will contribute to the Bay of Plenty Regional Council's planning and policy discussions in land use management. These data have also benefited other Scion-wide projects such as the Growing Confidence in Forestry's Future and other related projects.

BOPRC

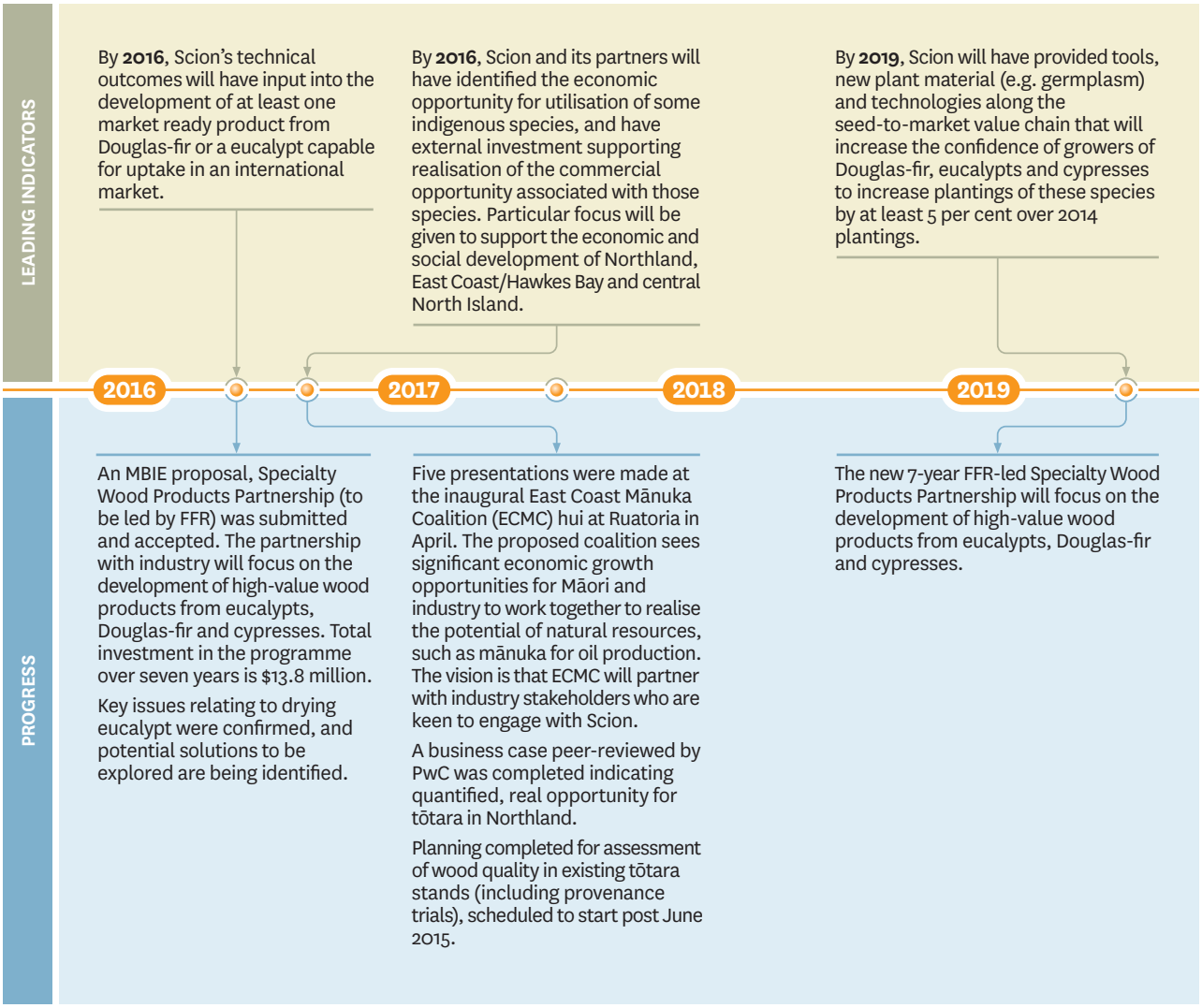
BOPRC

www.boprc.govt.nz/media/395767/ecosystem-services-in-the-ohiwa-catchment.pdf
www.scionresearch.com/ar15ecosystemvalue

Solid wood processing

IO2 – Increase the profitability of solid wood processing through customer solutions and supply chain innovations

Impact KPI-4: New seed-to-market value chains for specialty wood products. By 2019, Scion and its partners will have provided tools, new product options and plant material that will have supported the aspirations of growers and manufacturers to invest in new manufacturing facilities and expand plantings of Douglas-fir, eucalypts, cypresses and indigenous species based on increased confidence of securing highest possible value for their products along the entire seed-to-market value chain.



Tōtara's economic potential for Northland

A new forestry industry based on New Zealand tōtara could provide a substantial lifeline to a struggling Northland economy.

A multi-disciplinary team of Scion scientists has been working with Ministry for Primary Industries, Northland Inc., Tane's Tree Trust (TTT) and Northern Tōtara Working Group (NTWG) to explore the feasibility of establishing a new industry based on the extensive tōtara resources growing on private land.

An earlier study by TTT and NTWG suggests there may be over 100,000 hectares of tōtara (*Podocarpus totara* D.Don) regenerating in the presence of grazing, in privately owned forest and scrublands in the region. These resources have, until recently, been largely ignored and considered of little worth.

The region could benefit from the creation of a sustainable wood products industry developed around this resource provided the commercial opportunity can be properly developed and demonstrated. Such an industry would involve the development and marketing of high-value wood products from tōtara to replace imported products, and the generation of new business opportunities along the value chain. A preliminary business case shows a potential value of at least $11 million by 2017 and $110 million by 2021, based on timber values alone. This could leverage subsequent investment into expanding the tōtara resource.

“Due to the advanced age of a significant portion of the regenerating forest, payback from initial investment would be more or less immediate,” says Peter Berg, Chair of Tane’s Tree Trust. "What’s more, forestry with native species will be based upon continuous cover forestry practices. This means that harvesting will involve individual stems but the forested landscape will be permanent."

Tōtara is a resilient species able to establish and grow vigorously in various soil types under a variety of climatic conditions, and is also plentiful in other parts of New Zealand. It produces hard, straight grained wood and durable heartwood that is inherently resistant to fungal degradation when it has reached an appropriate age and diameter. Its versatility and properties give the timber considerable economic value.

The majority of the few remaining old-growth stands of tōtara are protected, however, the species’ ability to thrive under a range of conditions has meant individual trees and stands have readily regenerated on farmland.

A preliminary business case shows a potential value of at least $11 million by 2017 and $110 million by 2021, based on timber values alone. This could leverage subsequent investment into expanding the tōtara resource.

Previous research conducted by Scion has focused on both protecting and utilising tōtara as a commercial resource. While the growth rate of tōtara is unlikely to reach that of fast growing exotic species such as radiata pine, the increased value of the wood may compensate for its lower level of productivity. Scion is confident there is an opportunity to increase the productivity of tōtara through a genetic improvement programme and improvements to silviculture.

The recent review of tōtara’s economic potential for the region involved industry-wide engagement by all stakeholders, from government regulatory organisations to landowners, industry and end-users, and has taken a whole of region approach.

An independent market research company was contracted to review industry’s perceptions of, and requirements from, a possible tōtara-based industry. As Scion’s indigenous forest specialist Greg Steward says, industry involvement has been vital to the project, contributing their requirements for both volume production projections and quality.

“End-users have indicated a willingness to substitute tōtara products for imported resources,” says Greg. “Regulatory bodies have shown a willingness to review legislation and policy around the management and utilisation of the resource, adding scope for further development.

“Industry and stakeholders now have a much greater understanding of the true potential both in managing the tōtara resource and the financial outcomes, with the involvement of independent consultants adding rigour and a level of impartiality to the project.”

MPI, Northland Inc., TTT, NTWG

MPI, MBIE (PSAF), Scion Core, Northland Inc.

www.scionresearch.com/ar15totarapotential

Genomic selection for alternative species adds pace

Scion's Forest Genetics Team is building a number of new genomic technology platforms to support the genetic improvement of indigenous and alternative forest species. Genomic selection of forest trees has not previously been applied in commercial platforms in New Zealand.

"This makes it possible for tree breeders to select for multiple traits early in a breeding cycle and removes the need for expensive, long-term field trials."

"The new platforms will build on our experiences with radiata pine to introduce genomic selection into breeding programmes for these species," says Science Leader Dr Heidi Dungey. "Genomic selection increases the rate of genetic gain and accelerates the breeding cycle by using DNA markers to predict tree characteristics and genomic breeding values.

"This makes it possible for tree breeders to select for multiple traits early in a breeding cycle and removes the need for expensive, long-term field trials.

"We are developing one such platform in collaboration with AgResearch, which will be to international standards. This will include the collection of relevant sample populations, testing experimental protocols, and developing collaborations to generate genomic resources, such as genome sequences and genomic breeding values."

Scion has been developing genomic resources since 2012, building on more than 40 years of research into alternative forest species. Our geneticists have successfully developed DNA extraction methods for a number of recalcitrant tissues and species that are included in our emerging indigenous forestry portfolio.

"As part of our collaboration with AgResearch we will be testing new 'genotyping by sequencing' technologies," says Heidi. "This will involve the creation of 'skim' genomes for *Eucalyptus regnans*, *fastigata* and *nitens*. We're hopeful this new technology will create a more economical genomics model that will benefit breeding programmes.

"This year, we have already undertaken extensive phenotyping to initiate this in *E. nitens*."

Scion's Forest Industry Informatics Team has helped develop a sophisticated data storage and management system capable of handling the expansive datasets now being generated by these new genomic technology platforms. The new database is capable of integrating phenotypic data with the new waves of genomic information. Integrating the vast array of phenotypic and genotypic data in these databases makes it possible to create virtual datasets and to explore genetic-environment (GxE) interactions.

Genomic selection for the alternative species, including eucalypts and Douglas-fir, is currently aligned to the new MBIE Specialty Wood Products Partnership. This Future Forests Research-led programme aims to create a high-value wood products industry from planted forest species other than radiata pine.

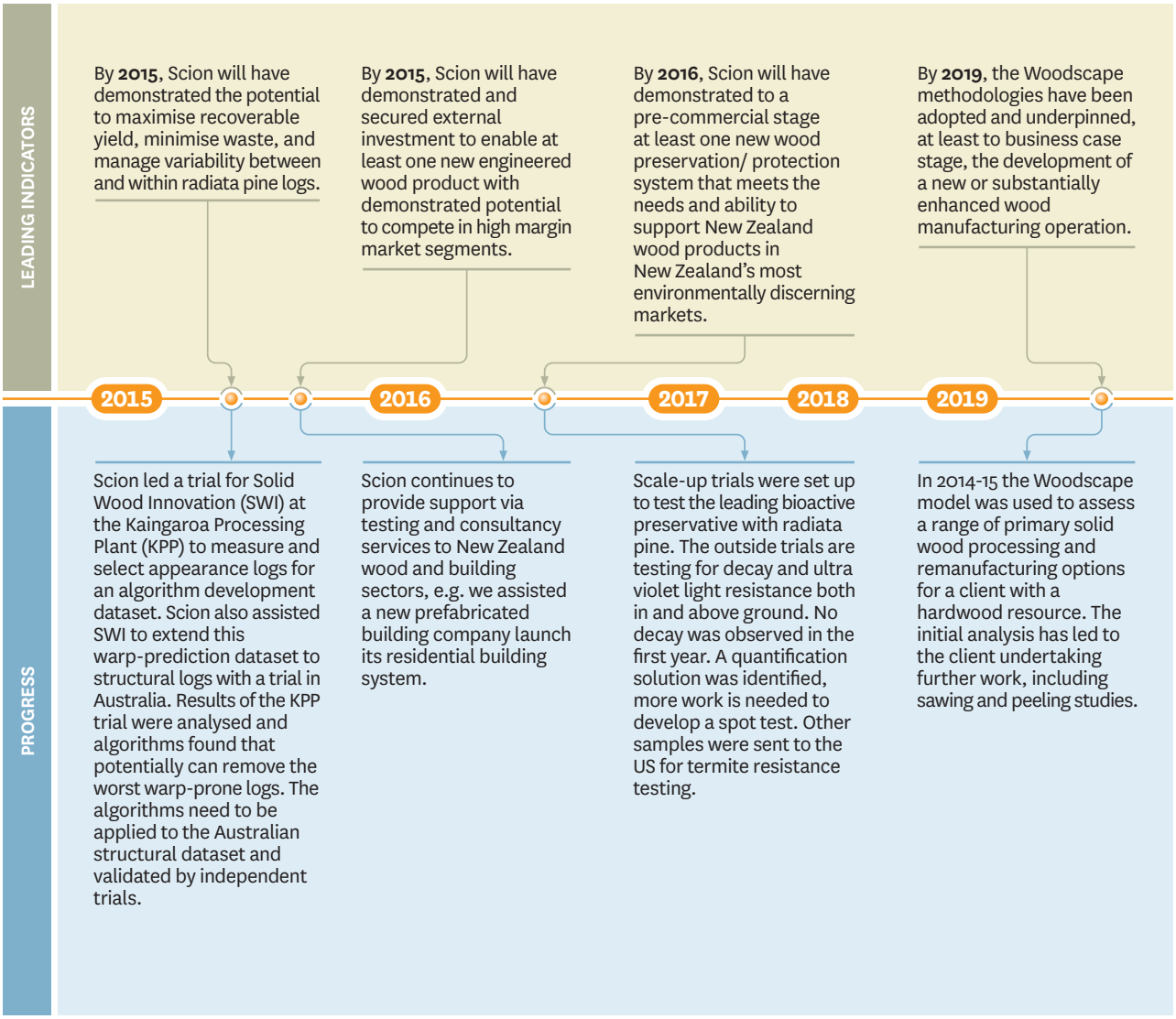
This seven-year research programme represents a total of $13.8 million investment comprising $710,000 per annum from MBIE's Biological Industries Fund, $710,000 per annum from the forestry industry, $550,000 per annum from Scion Core Funding and support from the School of Forestry, University of Canterbury.

FFR, AgResearch, University of Canterbury

MBIE, Scion Core, FFR

www.scionresearch.com/ar15genomicselection

Impact KPI-5: Expand opportunities for wood products and systems. By 2019, Scion will have supported wood processing and manufacturing companies by delivering new productivity enhancing tools and technologies that assist them to meet their growth targets and encourage increased investment in wood-based manufacturing in New Zealand.



Extracting valuable chemicals from bark, leaves and needles

Scion scientists are using transformative wood dewatering technology to investigate new specialty wood products and wood-based chemicals from tree species other than radiata pine. Dewatering uses supercritical carbon dioxide to extract water from wood, resulting in wood that is receptive to further modification. The liquid extracted during this process contains a range of bio-based chemicals that also generate an additional revenue stream.

Until recently, our work in the dewatering field has focused on sapwood and heartwood predominately from radiata pine. Scientists are now turning their attention to other species, and to other parts of the tree that traditionally go to waste – bark, leaves and needles.

As a result, our chemists are making some exciting, and unexpected, scientific discoveries about bark and other tree tissues as a potential source of valuable phytochemicals.

Phytochemicals are naturally occurring chemicals that can be used in industrial processes (in some cases displacing petroleum-based chemicals), pharmaceuticals and nutraceuticals.

"These discoveries offer exciting possibilities in the future for 'whole-of-tree biorefining' where virtually none of the tree is left behind in the forest, and the tree's total resources are more fully utilised." says Research Leader Dr Stefan Hill.

"Extracting organic components from plant tissues is usually done using

traditional organic solvents, and is difficult to scale up," says Research Leader Dr Stefan Hill. "We used Callaghan Innovation's extraction equipment to run trials on bark and other plant tissues, such as needles and leaves, using supercritical carbon dioxide as the solvent. This works in much the same way as Scion's supercritical dewatering plant with the additional capacity to extract other compounds. The results were surprising – and very exciting.

"Further investigation of these extractives here at Scion, using nuclear magnetic resonance and other analytical techniques, has identified a group of chemicals that were previously not easily obtainable. With a high percentage of bark burned for energy or dumped, some valuable chemicals are currently going waste.

"These discoveries offer exciting possibilities in the future for 'whole-of-tree biorefining' where virtually none of the tree is left behind in the forest, and the tree's total resources are more fully utilised. It could lead to the creation of new onshore processing plants for the recovery of high value chemicals in addition to timber and other wood products, from both radiata pine and alternative forest species, including native tree species."

Stefan and his team have developed a metabolomics platform over the past few years for analysing dewatered sap extracts. This foundation was used and expanded to characterise dewatered sap extracts from alternative tree species, including Douglas-fir, tōtara and eucalypts.

Some of the phytochemicals recovered are highly functional chemicals that can be used to link polymers together to make bioplastics and bioadhesives, thus providing a source of naturally occurring ready-made polymer precursors.

"Considering just bark for the moment, the volume of phytochemicals extracted using supercritical carbon dioxide and hot water would equate to over 40-50 per cent of the original dry mass of bark," says Stefan. "These chemicals could be used as sustainable chemical feedstocks for many industries.

"What would be left in the bark after this process is an insoluble residue that is still a valuable source of energy due to its inherent calorific value. This reinforces the whole-of-tree concept."

We are expanding Scion's metabolomics platform with some of the latest technologies that will take us to the next step in the development of alternative species extractives and specialty wood products.

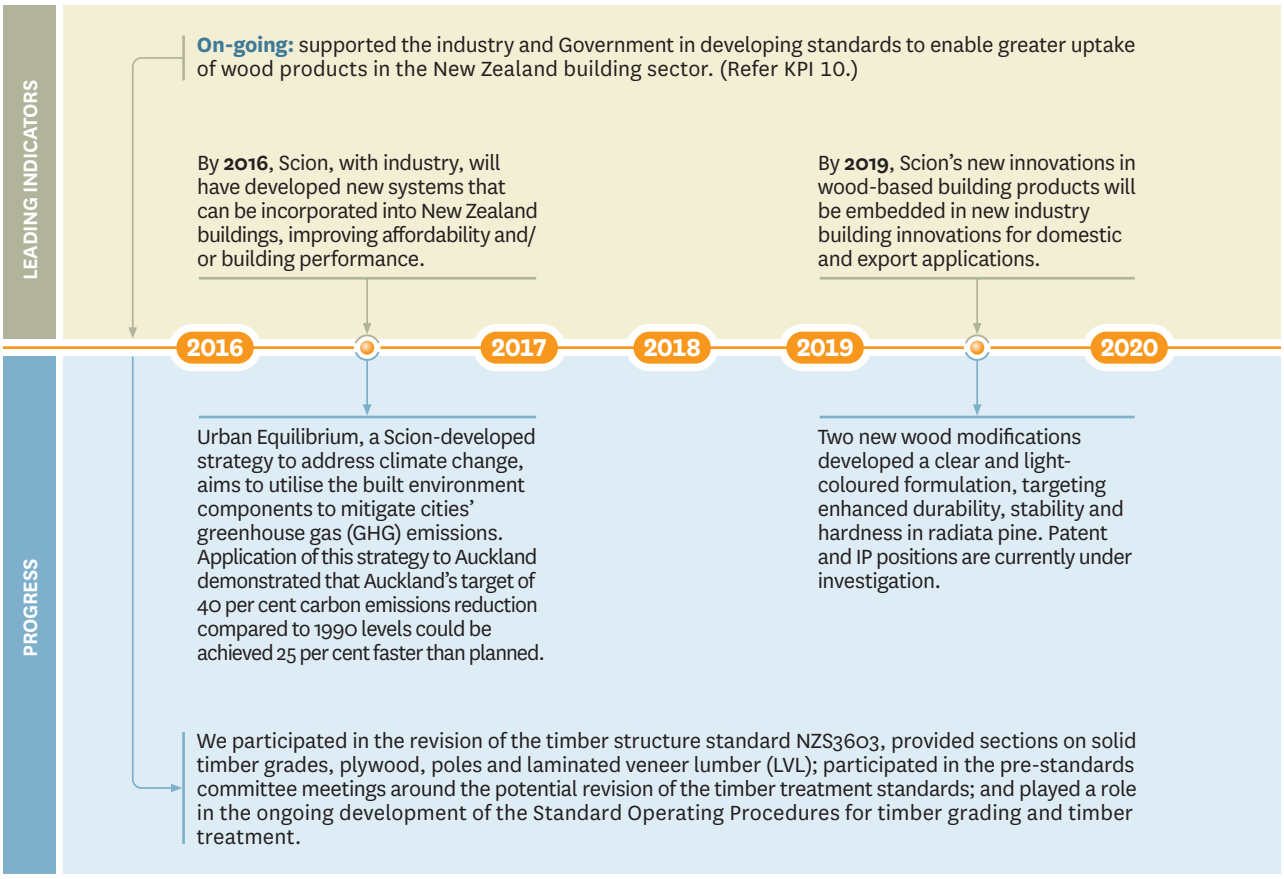
Beyond the traditional sapwood and heartwood from the forestry industry, there is a large resource of bark already in existence and the possibilities of what is hidden in leaves and needles are not yet fully explored. Considering the diverse range of tree species available, this equates to a huge untapped potential within the forestry industry.

Callaghan Innovation, University of Würzburg (Germany)

Scion Core

www.scionresearch.com/ar15extractingchemicals

Impact KPI-6: Cost effective and resilient buildings using New Zealand wood-based materials. By 2019, Scion product solutions will be embedded in new constructions to support the New Zealand wood products industry to increase the use of wood and wood-based products in residential and light-commercial applications and help grow their projected revenues to an additional $115 million per annum by 2022 through exploitation of off-site building processes.



Storing carbon within the urban environment

Urban Equilibrium is a strategy to address climate change by using timber-based building materials that sequester and store carbon, and help reduce greenhouse gas (GHG) emissions. The strategy aims at maintaining a balance between humanity and the natural environment, which in New Zealand, is reflected in the traditional Māori kaitiakitanga principles of stewardship.

In 2013, Scion was engaged by Sequal Lumber in Kawerau to evaluate the contribution made by 'massive timber construction' technologies to balance urban carbon emissions, within the urban equilibrium model. The use of solid wood technologies and engineered wood products such as cross-laminated timber, glulam and laminated veneer lumber, as opposed to conventional technologies, compounds the amount of timber used in construction, thereby increasing the environmental benefits contributed by wood.

Substituting building materials would reduce manufacturing emissions by 38 to 65 per cent, and prefabrication would reduce construction emissions by up to 13 per cent.

"Urban Equilibrium presents a strategy to help greenhouse gas mitigation while meeting a city's future growth need," says Andrea Stocchero, a sustainable architect with Scion's Built Environment Team. "There is scientific evidence on the carbon sequestration rates of forests and long-term carbon storage rates in timber products. We can therefore calculate the amount of carbon sequestered within the built environment, starting with the volume of timber used in solid timber buildings.

"Evaluating the environmental benefits of using timber in construction is not new, but studies have only been done on single dwellings until now. The novelty of this project is to evaluate those benefits at an urban scale.

"With the move to more, and larger, cities it is becoming more important for the built environment to balance its greenhouse gas emissions. The urban equilibrium strategy allows for future urban development to be considered as a resource to mitigate those emissions. We used Auckland as an exemplar of what is possible."

About one-third of the country's population currently live in Auckland with this expected to increase by about one million over the next 30 years. Auckland Council's Plan also sets a target to reduce the city's GHG emissions by 40 per cent by 2040.

Scion's research team compared the Auckland Plan's GHG emission mitigation rate with what could be achieved using urban equilibrium development principles over a 30-year period. Calculations were based on the forecast growth of residential, social and commercial buildings laid out in Auckland Council's Unitary Plan.

"Our study showed that council could achieve their emissions reduction target 25 per cent faster than planned by applying urban equilibrium to their forecast growth," says Andrea. "By year 30, sustainably managed forests supporting new urban development would be sequestering carbon at a rate equivalent to 6.6 per cent of Auckland's 2009 GHG emissions, with the amount of timber needed to sustain this level of growth, providing long-term carbon storage for a further 6.6 per cent.

"Using massive timber technologies would provide other benefits too. For example, substituting building materials would reduce manufacturing emissions by 38 to 65 per cent, and prefabrication would reduce construction emissions by up to 13 per cent. Other emissions savings would be made at end-of-life by landfilling the timber waste or using it as a substitute for fossil fuels to generate energy.

"Our study showed that while there is a need for a top down approach to urban equilibrium from central government, urban decisions can play a significant role in achieving a more sustainable environment."

Executive Director of Sequal Lumber, David Turner, says the urban equilibrium concept provides an analytical framework to discuss how we urbanise, and elevates the discourse on the structural nature of urbanisation from a set of products to a set of values.

"If we value sustainability, co-existence and intergenerational equity then these values need to be the starting point from which we design how we choose to exist," says David. "Scion's research shows that achieving these values and urbanisation do not need to be mutually exclusive, and the use of timber is central to achieving both outcomes simultaneously. Their findings affirm what the timber industry has promoted for some time - that timber means more than wood."

The case study was completed at the end of 2014 with a scientific paper pending publication.

Sequal Lumber

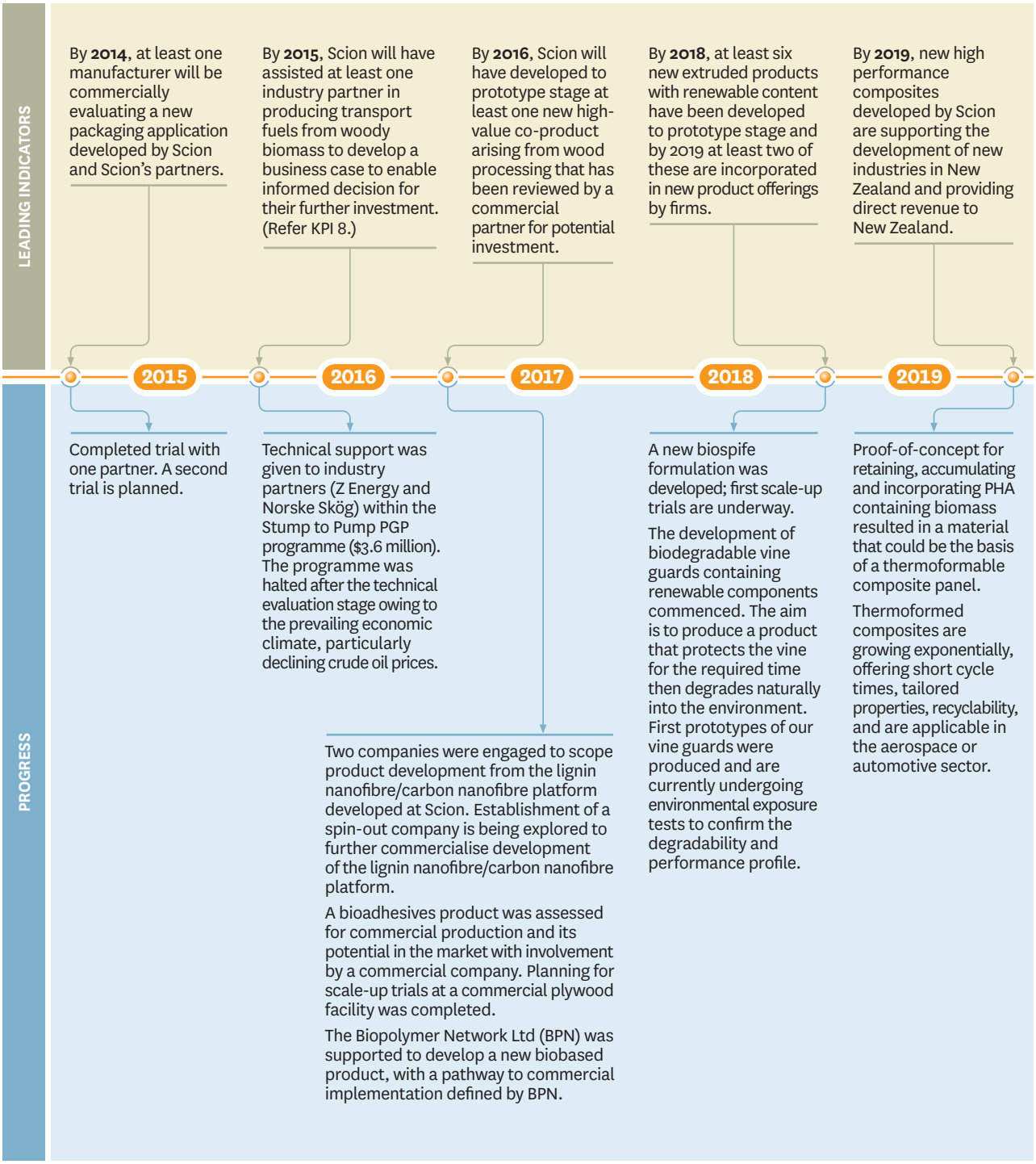
Scion Core, Sequal Lumber

www.scionresearch.com/ar15storingcarbon

Wood fibre, pulp, biopolymers, packaging and biochemicals

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

Impact KPI-7: Develop new wood and fibre-based manufacturing industries in New Zealand. By 2019, new capital investment will be occurring in new manufacturing industries in New Zealand as Scion's developments in new high-value products derived from forest materials are being adopted.



Transforming bio-waste into valuable composites

A revolutionary technology, developed by Ashburton-based company LignoTech Developments Ltd, is attracting interest internationally for its ability to transform agricultural waste into eco-friendly ingredients used to make bio-plastics and composites.

The technology transforms bio-waste into a replacement for petrochemical and mineral fillers that are used in the manufacture of plastics and composites, adding considerable value to what would otherwise be livestock feed or go to landfill.

The project is a result of a collaboration between LignoTech Developments Ltd, research partner Scion and Reichhold Inc, one the world's largest suppliers of unsaturated polyester resins for composites. LignoTech's patented steam explosion technology 'pressure cooks' lignocellulosic (woody) residue, such as dried distillers grains and corn fibre, making it amenable to further processing.

The powder produced from this process can then be incorporated into both thermosets (sheet moulding compound SMC, and bulk moulding compound BMC) and thermoplastics, such as high density polyethylene compounds. The end product is lighter, stronger and more durable than those made with dense, heavy calcium carbonate.

The powder particles are also smaller and uniformly sized so can be more evenly distributed, resulting in a superior surface on the final moulded product. This is a boon for the automobile industry in particular, where high quality paintable surfaces are a requirement.

The LignoTech - Scion partnership has been running for over seven years. During this time Scion has helped LignoTech optimise their material and develop thermoplastic and thermoset composites for property testing. We have also adjusted their process to produce a less moisture absorbent material.

After fire destroyed their Ashburton facility in December 2012, LignoTech took the opportunity to build a plant with increased capacity in the US, and with access to an abundant supply of raw material. The corn-ethanol industry in the US alone, generates over 40 million tonnes a year of dried distillers grains and solubles as a by-product.

The process adjustments developed at Scion have been incorporated into the design and construction of the new production facility in Kearney, Nebraska. Scion continues to support LignoTech with their US plant design and trialling our new technologies with their industrial clients.

LignoTech Developments Ltd; Reichhold Inc. (US)

LignoTech/Xylemer Bio-Products

www.scionresearch.com/ar15transformingbiowaste

New barrier coating adds value to packaging

Horticultural exports are worth an estimated $4.7 billion to New Zealand, with a large majority distributed through the chilled supply chain in cardboard boxes. Ensuring these products reach the consumer in good condition is an ongoing challenge for the chilled goods supply chain, where cardboard boxes are exposed to fluctuating humidity. This can cause changes in moisture content and premature failure of the boxes, resulting in costly product loss.

Scion's Packaging Team has developed a new moisture barrier coating designed to increase the lifetime of paperboard in humid conditions. Applied over ink, the coating also provides a high level of gloss that protects package branding and offers good scuff resistance so the visual impact of the product is maintained right through to the end user.

Key to its success is the flexibility of its application. The coating can be applied using an industry-standard flexographic printing press. This enables multiple thin layers to be applied, which reduces both total volume of coating required and the costs incurred. It also provides superior barrier performance with fewer cracks on the coated surface than conventional coatings.

Scion has been researching moisture coatings for paper for many years. The challenge has been to come up with a coating that could work on both a conventional coating line and a flexographic press, due to the fundamental differences between the two technologies.

Conventional moisture coatings normally consist of mineral pigments,

such as clay and talc, in a polymer latex. These are traditionally applied in a single, thick layer on packaging coating lines, which are not available in New Zealand. Packaging companies therefore need to maintain a stockpile of imported coated packaging material on hand.

Conversely, flexography is a simple printing method often used to print directly onto packaging such as sacks, bags or boxes. The inks used are very fluid so they can be used to print images and text. A single printed ink layer is much thinner than a barrier coating, and presses are normally equipped with 4-10 inking units making it possible to apply multiple layers at once.

Due to its flexibility of application, Scion's new barrier coating will now make it possible for packaging companies to apply barrier coatings in-house as required, without the need for further investment in costly equipment. It will also mean less product loss and happier customers.

The barrier coating technology has been successfully tested at pilot scale at Karlstad University in Sweden. Scion's investment in an in-house printing press has now made it possible to conduct further trials on site, and test packaging performance in our purpose built coolroom box compression creep facility, which stimulates conditions in the chilled supply chain.

Trials run recently on two commercial flexographic presses in New Zealand

have confirmed that Scion's formulation can be applied without damaging commercial equipment. The first trial was application on to paper and the second more recent trial directly on to corrugated cardboard boxes.

"Scion's new barrier coating was run successfully on a flexographic press and the results were quite promising for a first up trial," says Gerry Lenting, Key Segments Manager at Carter Holt Harvey. "We would expect performance improvements to be achieved with further trials as the interaction between the coating, the application machinery and the substrate being coated is better understood."

This research opens up further opportunities for packaging manufacturers who have an in-house printing press to add value to their packaging. For a $4.7 billion industry, even small savings in product loss through less box failure will amount to a considerable saving for the industry.

CHH

Scion Core

www.scionresearch.com/ar15newbarriercoating

Cost-effective solution helps our customers grow

In 2012, Scion was engaged by New Zealand plastics manufacturer, Adept Plastics, to advance their non-toxic, dissolvable injection moulding compound for water soluble animal/meal processing devices. Adept Plastics is a pioneering leader in the meat processing and medical sectors, supplying 95 per cent of Australasia's abattoirs.

The soluble processing devices replaced the non-degradable plastic plugs previously used in meat processing, which required employees to extract them. As a result, the plugs were often overlooked with renderers and pet food manufacturers having to recover these items further downstream.

The soluble compound is lightweight and inexpensive to formulate, making it commercially viable to process and the end product a cost-effective option for Adept Plastic's customers. Adept Plastics since built on their research and development investment by installing their own specially designed extrusion line, in consultation with Scion's Biopolymers and Composites Team, followed by a short secondment by one of our scientists to provide practical assistance.

This new attribute of benign rapid dissolvability distinguishes Adept Plastic's products from others and, with the new custom extrusion line, has enabled them to generate new sales by making tailored dissolvable products. This has supported on-going employment with further expansion of the company planned.

Adept Plastics won a gold award for these products at the 2014 New Zealand Plastics Industry Design Awards in October.

Adept Plastics

Adept Plastics

www.scionresearch.com/ar15adept

Energy security

IO4 – Increase New Zealand's energy security through the use of forest biomass, clean technologies and industrial symbiosis

Impact KPI-8: Diversify the products of existing firms in wood processing, pulp and fibre production in New Zealand. By 2019, Scion's product and process developments will be embedded in existing wood processing industries to support them build greater economic and environmental resilience through diversification of their product offerings and reduced environmental impact.

LEADING INDICATORS

By **2015**, Scion will have delivered at least one commercial solution to a firm or waste material treatment entity for the conversion of liquid or solid rich organic wastes into recoverable products to maintain BATEA (Best Available Technology Economically Achievable).

By **2016**, Scion will have supported the pulp industry in evaluating at least one new high-value co-product from their operations.

By **2018**, Scion will have supported a group of firms in one region to develop a value proposition, based on industrial symbiosis, outlining the benefits/risks across economic, social and environmental criteria, enabling them to make an informed decision for action.

2015 | 2016 | 2017 | 2018 | 2019

PROGRESS

TERAX™ technology was demonstrated at pilot scale at Rotorua Lakes Council (RLC) wastewater treatment plant. A decision from RLC on the deployment of the technology at commercial scale is awaited.

An electro-separation process to remove resin from pulpmill liquid streams was successfully developed. Next steps are to scale up to process and complete the business viability assessment.

Contract lab-scale trials were carried out for a client to modify a pulping process to produce paperboard with improved strength when exposed to a cycling humidity environment. This work was successful and is ready to scale-up.

The MBIE-funded Industrial Symbiosis project began analysis for two case studies and identified five opportunities for further analysis with the co-funders.

Market access and risk management

IO5 – Protect and enhance market access and improve risk management in the forest industry including forest health and preparedness for biosecurity incursions, fire and climate change

Impact KPI-9: Ensure New Zealand forests are resilient to current and future natural threats. By 2019, new tools and technologies will have been developed to quantify and mitigate impacts from the increasing risk to New Zealand's forests from pests, fire and wind, and climate change, and will have been adopted by forest industries, land owners, and central and regional government.

LEADING INDICATORS

On-going: the National Forest Herbarium and the Forest Health Collections and Databases remain viable and provide valuable information on the national forestry position for New Zealand.

By **2016**, Ministry for Primary Industries will have adopted a new tool or method developed by Scion and Scion's research partners to enable early detection and/or eradication of a pest to New Zealand's forests.

By **2016**, Scion will have identified radiata pine germplasm with improved resistance to at least one foliar disease.

By **2016**, rural fire stakeholders through the Rural Fire Research Advisory Committee will have adopted new fire behaviour models or adopted enhanced data collection systems that lead to both enhanced fire fighter safety and intelligence for fire fighting decision making.

By **2017**, there will be at least two examples of policy makers or forest growers using Scion's models and tools to quantify and mitigate the impact of climate change or severe weather.

By **2018**, options to reduce the impact of *Phytophthora* on radiata pine, kauri and one horticultural species have been identified.

2016 **2017** **2018**

PROGRESS

The forest biosecurity surveillance system was re-designed to expand coverage from plantation forests to all areas where forest pests could first establish. Prototype pest establishment and surveillance optimisation models were developed. In 2015-16 these will be tested with the aim of full operational deployment in 2016-17.

Laboratory-based testing of *Pinus radiata* germplasm from the RPBC's Elite Clone lines has identified lines that are either more susceptible or more resistant to *Phytophthora pluvialis*, the causal agent of red needle cast. This finding augers well for the eventual deployment of resistant lines on disease prone sites.

Wilding conifer burning trials have been prepared for ignition this coming spring. The trials will provide data to improve the conifer burn models utilised in the Fire Behaviour Calculator and Prometheus Wildland Fire Growth Model. Prometheus was used operationally at several wildfires during the past summer to assist fire management decision making (e.g. fire suppression resource allocation, community evacuations). A prototype UAV fire hot-spotting system for locating areas burning, not visible to the naked eye, was developed and is being tested.

One forest manager is already using Scion's models to assess the risk of wind damage when scheduling thinning operations. The impacts of future climate change on the risk of wind damage were assessed and recommendations made on how forest growers need to modify their silvicultural regimes to mitigate this risk.

Laboratory studies showed that both phosphite and copper oxide are promising chemicals to control red needle cast on *Pinus radiata*. Preliminary studies looking at chemotaxis (chemical stimuli that could attract or repel *Phytophthora* zoospores) also showed good promise as another method to reduce impact of *Phytophthora* in both natural ecosystems and plantations.

Herbarium now offers high resolution images of specimens online. Gaps in the collection of New Zealand cultivated woody species were identified and are being addressed with the help of external partners. During the year, >700 specimens were added and >300 requests for identification or botanical information were addressed.

Innovative fire behaviour tools prove their worth

As a result of over 20 years of collaborative research between Scion and New Zealand's National Rural Fire Authority (NRFA), rural fire managers have access to a range of innovative fire behaviour tools that have been developed or adapted specifically for New Zealand conditions.

"We work closely with fire managers, rural fire authorities and other research organisations to ensure the models and tools we develop are relevant and validated by rigorous science," says Scion fire scientist Veronica Clifford.

These were put to the test in February by Scion fire scientist Veronica Clifford. Veronica served as technical specialist for the National Incident Management Team deployed to manage wildfires that swept through 600 hectares of forest at Onamalutu, in Marlborough.

The fire destroyed forest and farms, and threatened numerous homes and properties. It took the efforts of 15 aircraft, 180 fire fighters plus an NRFA national incident team to bring the fire under control, with an estimated cost of $1.4 million.

Using the Prometheus fire behaviour model and the New Zealand Fire Behaviour Toolkit, Veronica was able to provide fire weather forecasts, and fire behaviour and growth predictions for the Marlborough/Kaikoura Rural Fire Authority (MKRFA). These predictions formed the basis of operational decisions made around resource deployment and possible evacuations.

"By taking into account weather conditions, the lie of the land and vegetation, and the way they interact, we can go a long way to predicting the behaviour of most fires," says Veronica. "I used up-to-date weather forecasts for the area and other information to predict what the fire was likely to do over the next 12-hour period. Then I briefed management and the fire crews at twice daily shift changes."

Richard McNamara, Principal Rural Fire Officer for the MKRFA said having Veronica on the team meant fire crews received real time advice on a complex fire, with multiple fuel types on rough terrain.

"We used Veronica's predictions to make decisions as to where to concentrate firefighters and aerial support, and when evacuations might be necessary.

"The wind changing direction was especially concerning. When we knew a southerly change was on its way, Veronica and I tracked its progress closely. The fire crews were working amongst tall timber at the time and there was a risk of weakened trees toppling when the wind changed."

Following a post-event review of the fires, Veronica used Prometheus to demonstrate the likely behaviour and magnitude of the fire without suppression, and illustrate the "values saved" by the firefighting efforts.

Prometheus is Canadian software that has been adapted for use in New Zealand and validated against a number of historical New Zealand wildfires. The model can be used for a range of applications including forecasting wildfire growth, providing post-fire support for wildfire investigations, and planning prescribed burns. It can also be used to conduct "what if" scenarios to support readiness and reduction planning as part of the

Strategic & Tactical Fire Management Planning process.

In the case of the Onamalutu fire, it was used to develop evacuation plans by identifying threatened communities and possible egress.

The Prometheus model was also used in a post-fire review of a wildfire that threatened the South Canterbury township of Twizel in January. This demonstrated the effectiveness of fire suppression efforts taken and the values saved by comparing actual fire spread with modelled potential fire spread. Results from this modelling have sparked interest from the community to establish a green break around the town for future fire protection.

"We take a hands-on approach to fire research," says Veronica, who is also a volunteer rural firefighter. "We work closely with fire managers, rural fire authorities and other research organisations to ensure the models and tools we develop are relevant and validated by rigorous science. The results of this collaborative research help support the critical decisions made by rural fire managers."

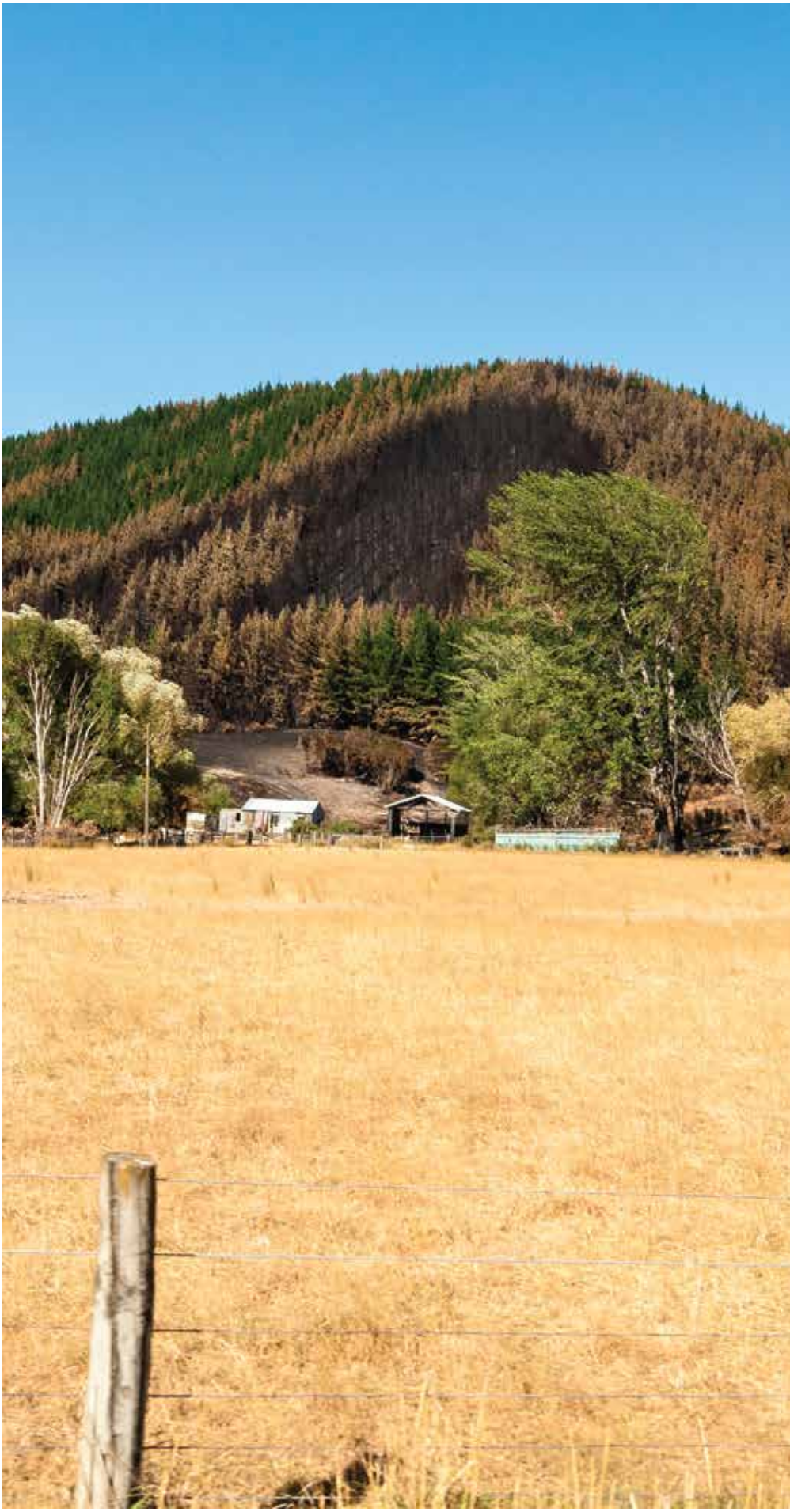
The Prometheus adaptation project was initially funded by DOC in 2009-10, followed by a 10-day secondment by Veronica at DOC to further investigate the use of Prometheus for strategic planning purposes.

In 2010, Scion's Rural Fire Research Team trained DOC staff to use Prometheus. Last year a further 46 New Zealand fire personnel were trained in Prometheus with fire managers using it for a range of operational and strategic planning purposes. Due to ongoing demand, Scion will be continuing to run training and refresher courses to ensure there are sufficient skilled operators around the country.

Alberta Sustainable Resources & Development; Heartland Software Solutions (Canada)

Rural fire users including DOC, NRFA, NZFS, LGNZ, NZFOA, NZ Defence Force

www.scionresearch.com/fpsciencereport2014
www.scionresearch.com/ar15firebehaviourtools



Licence to operate

IO6 – Ensure the forest industry's licence to operate (and reputation) through workers' safety and capabilities, verifiable environmental performance, product traceability and modern standards; and, by anticipating long-term change

Impact KPI-10: Sustain the New Zealand forest and wood product industry licence to operate. This is an underpinning group of activities with broad impact across the forestry and forest products (and related) sectors. By 2019, Scion has supported the industry to enhance its licence to operate.

LEADING INDICATORS

On-going: support the New Zealand export industry by developing new options for products such as packaging to enhance acceptance of New Zealand products in international markets.

By **2015**, Scion and the forestry industry will have identified those specific activities where Scion can assist the industry in meeting its targets for improving worker safety.

By **2016**, Scion with its research and industry partners, defined a strategy to reduce the use of phytosanitary treatments, specifically methyl bromide, by at least 30 per cent, and this will be presented to the Ministry for Primary Industries for evaluation and subsequent adoption by industry.

By **2016**, the benefits and risks of genetic modification research will have been quantified and presented to the forest industry, government and other key stakeholders for an informed decision on its future.

By **2016**, Scion will have (i) supported forest industries to maintain access to cost effective herbicides and management options for the environmental certification of New Zealand forests, and (ii) agreed with stakeholders' research priorities for reducing wilding conifer impacts.

2016 2017

PROGRESS

A human factors scientist was recruited to expand Scion's research capability in human performance and systems safety across the forestry value chain. This capability has facilitated engagement with forestry stakeholders across New Zealand and alignment with the latest research in human factors, safety and performance across numerous industries. Development of safe work methods in motor-manual tree felling progressed, along with several other strategic initiatives, to help solve identified safety issues within the forest industry.

A prototype landscape model of forest insect abundance was developed and presented to STIMBR and MPI. The model will support the case for a potential future phytosanitary treatment free winter period. A national network of forest insect traps collected insect population numbers within the forests and at key export ports over 2.5 years. A new online data visualisation tool now makes data available in a secure format to stakeholders. Data from this network led to a provisional extension of the post fumigant exposure period at Northport to 21 days in winter, bringing consistency to post fumigation log handling procedures throughout New Zealand.

Input was made into the growing biotechnology debate occurring in New Zealand around the potential benefits of biotechnology and current road-blocks in the regulatory framework on biotechnology. This is occurring through interactions with schools, the public, government, regional councils and industry. Examples include interactions with NZFOA, CHH, NZBio workshop on GM technologies and contributions to regional council submissions.

Two papers describing the environmental fate of terbuthylazine and hexazinone in a planted forest environment were published in 2015. They indicated little to no impact to soil and water quality in Pumice soil. This work was key to supporting continued use of terbuthylazine and hexazinone on FSC certified land and possibly supported their removal from the list of FSC prohibited herbicides. Results were used in development of best operational practice standards for use of terbuthylazine and hexazinone in the Auckland Council drinking water supply catchments.

Staff participated in workshops and EU programmes on developing standards for bioproducts. This included Open-Bio and KBBPPS (Knowledge Based Bio-based Products' Pre-Standardization) workshops and meetings. Open-Bio is the follow-up project to the EU-wide research project, KBBPPS.

Crucial insights from long-term productivity trials

Scion's forest systems scientists are demonstrating the value of long-term research to the sustainable management of planted forests.

"A series of long-term productivity trials established some 30 years ago offer us a unique opportunity to assess changes in soil nutrient status over successive forest rotations," says soil scientist Loretta Garrett. "These data will help address the uncertainty around the ability of many planted forest soils to supply nutrients over multiple rotations."

"This is a globally important question that we are contributing to, while also ensuring that New Zealand forestry's licence to operate is maintained under new intensive management practices."

Understanding how forest management practices affect a site's resources is critical to long-term sustainability. Given the rapid growth and short rotation times of our forests, this issue is of particular relevance to the New Zealand forest estate.

"A key goal of all forest growers is to maintain or increase productivity," says microbial ecologist Dr Simeon Smaill. "This becomes more important as some radiata pine plantings are now entering their third or fourth rotation.

"Information from the long-term trials will be used to refine the nutrient balance model NuBalM, improving the precision of nutrient management in existing and future forest rotations and providing for long-term nutritional sustainability."

The long-term productivity trials were established between 1986 and 1994 on sites across a range of climates, soils, and physiography to study the impacts of harvest and fertiliser activities on productivity of the second rotation of trees. As part of the Growing Confidence in Forestry's Future (GCFF) programme, our scientists are currently measuring nutrient pools in the forest ecosystem at the Woodhill and Tarawera trial sites. These tests were initially conducted prior to harvesting the first rotation at these sites. Comparing nutrient pools at the end of the first and second rotations will provide valuable data that can be implemented in NuBalM to better predict the effects of harvest removals and fertiliser application on productivity over single or multiple rotations.

The effect of fertiliser addition on wood quality is also being examined. The Woodhill trial site received large amounts of nitrogen fertiliser and will provide valuable end-of-rotation data linking wood properties to variations in nutritional factors. The results will be used to develop models relating wood formation to a wide range of environmental factors, and provide forest managers with new information on the wider impacts of manipulating site nutrition.

The GCFF programme has been running since October 2013. Early results are already addressing the knowledge gap that currently exists around what happens to soil resources over multiple rotations. Results from the Woodhill trial were presented at the GCFF annual conference in March this year, which was attended by industry and government representatives. Sampling of the Tarawera trial is also well underway.

"The programme is providing crucial insight into the future productive potential of our planted forests," says Loretta. "Early results from this programme are already raising the awareness of forest growers about the nutrients that are required to maintain the long-term sustainability of these planted forests.

"This is a globally important question that we are contributing to, while also ensuring that New Zealand forestry's licence to operate is maintained under new intensive management practices."

University of the South, Sewanee, Tennessee (US)

MBIE, NZFOA

www.scionresearch.com/ar15productivitytrials

Minimising environmental impacts of forest herbicides

Since 2012, Scion's Weeds Team has been studying the long-term effects that a number of key herbicides used in New Zealand planted forests have on the wider environment. The research programme is based around maintaining the forestry industry's licence to operate and includes identifying acceptable herbicides, reducing spray volumes and investigating the fate of herbicides in different forest environments.

"Continued use of herbicides depends in part on whether they break down in forest soils or leach into waterways. The FSC-certified forest industry needs robust data that shows what impacts key herbicides have on the environment," says pest management scientist, Dr Carol Rolando.

"Forestry companies that are Forest Stewardship Council (FSC) certified need to demonstrate that they are using herbicides in an environmentally acceptable manner," says pest management scientist, Dr Carol Rolando. "Continued use of herbicides depends in part on whether they break down in forest soils or leach into waterways. The FSC-certified forest industry needs robust data that shows what impacts key herbicides have on the environment."

This information can be used to make independent assessments of the environmental risks associated with operational management programmes involving herbicides. If the risks to water quality are shown to be negligible, the evidence can be used to support grant applications for their continued use. This approach was used for terbuthylazine and hexazinone, which were prohibited for use on certified forest land between 2007 and 2015.

Our research has played a key role in supporting the continued use of terbuthylazine and hexazinone under derogation on FSC-certified land between 2012-15, and likely supported their removal from the list of FSC-prohibited herbicides in 2015. With terbuthylazine and hexazinone being the most effective and widely used herbicides in New Zealand planted forests, this is a very positive outcome for the forestry sector.

"We have also been able to apply our knowledge about the movement of these active ingredients through the soil profile and across the recently planted environment to help Auckland Council establish streamside management zones in the Hunua Ranges," says Carol. "This allows terbuthylazine and hexazinone to be applied to forest land adjoining sensitive water catchments in the area while young growth is still establishing.

"This was an excellent opportunity for our scientists to use the fundamental knowledge we have gained through process research, to an applied outcome."

Scion's research on minimising the environmental impacts of forest herbicides has supported the forest industry's licence to operate as FSC-certified. Certification is a powerful market access tool without which, the forest industry's access to global wood and wood products markets could be restricted.

This work was presented at the New Zealand Forest Owners Association (NZFOA) Annual Conference in 2014, and also at the Growing Confidence in Forestry's Future field day in March 2015. Scion's Weeds Team received the NZFOA Award for Sector Communication and Engagement in 2014.

AgResearch, FSC Cluster Group, FGLT

https://www.youtube.com/watch?v=i9zabK1SR1A

www.scionresearch.com/ar15forestherbicides

Working with Māori

Success for Māori is also success for New Zealand.

As substantial land holders of commercially forested land, Māori are a critical part of the New Zealand forestry story and will continue to become even more so as Treaty settlements return more land and forests to iwi. The future of New Zealand's forest industry, and the types of products the industry will be producing in 10 or 20 years' time, will increasingly be influenced by Māori as either active participants in commercial forestry or by the decisions they make on how their land will be used.

In 2014, Scion revised its Māori plan in conjunction with our Ngā Rangatira. We set our leading indicators of success to be:

1. Scion and Māori are actively partnering and jointly investing to support Māori economic development through their forestry assets.
2. Māori and Scion staff are working in each other's organisations and learning from each other.
3. There is increased investment into Scion research programmes that directly support Māori aspirations.

Scion's programmes in partnership with iwi are continuing to grow with a greater involvement between Scion staff and our iwi partners. Some examples are listed below.

A hui was held in collaboration with Te Puni Kokiri and the Forest Growers Levy Trust, where research and development being co-funded by the levy was shared with Māori trusts and incorporations that are involved, or aspiring to be involved, in forestry. In return, those groups shared their experiences and plans for forestry, with all parties able to identify areas of mutual interest and future focus. The hui provided valuable insights on what is important to Māori in research programmes in New Zealand. We plan to continue hui in the regions in 2015-16 to build direct links with trusts and incorporations, and transfer forestry research findings.

Iwi are investing more in forestry programmes. For example, two iwi

clusters are developing their own forestry development and management strategies; and the Toitu Te Waonui initiative is looking at ways to increase forestry on currently under-utilised land with the help of third party investors. Direct investment by Māori was also made into a new national programme to realise greater value from eucalypt species, Douglas-fir and cypresses, and into evolving programmes in indigenous forestry and products. Special focus is being placed on tōtara and manuka (and their product value chains), and the commercial propagation of these and other indigenous species.

Crown research institutes are collectively partnering with Māori. Examples include: a partnership with Maniopoto Māori Trust Board to support land-based economic development options for Maniopoto; and with the Centre of Integrated Biowaste Research, an ESR-led programme, to engage the community over re-use options for biosolids. In June 2015, the CRIs in collaboration with Māori, hosted the Te Ara Pūtaiao hui to help re-connect iwi and hapu with science and technology.

Scion entered into a partnership with local Te Kura o Te Whakarewarewa primary school to introduce Māori children to science. At the same time, the children are challenging Scion's scientists to understand their world view. Our scientists and the students are working together to monitor the health of a local stream. The programme is now being extended by the school to include other science areas from Scion.

Helping to protect tāonga species and support community resilience is a special focus for Scion. During 2014-15, we continued to help East Coast Māori protect the endangered ngutukaka species, developed forest strategies to build community resilience in the fragile environment of the Waiapu Catchment area, and worked with Northland Māori through the Tangata Whenua Rōpu of Te Tai Tokerau to help find solutions to kauri dieback disease.

www.scionresearch.com/scion-maori-plan
www.scionresearch.com/ar15maori

Reaching out

Collaborations

>50

universities and research institutes internationally

- **11** formal collaborations with Māori
- **5** National Science Challenges

www.scionresearch.com/ar15collaborations

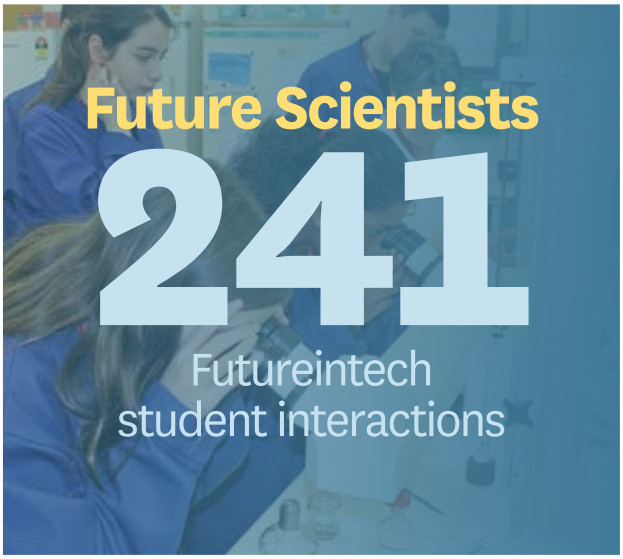
Tech Translation

339

external presentations

- **286** commissioned reports
- **130** conference papers (written & verbal)
- **22** magazine articles
- **13** events sponsored
- **13** programme newsletters
- **9** Forest Health News
- **5** videos
- **4** issues of *Scion Connections*

www.scionresearch.com/ar15techtranslation



Future Scientists

241

Futureintech student interactions

- **46** interns hosted
- **>200** school students visited
- **25** lab coats sponsored for a local school
- **5** winning students hosted for a day
- **30** university students employed in summer
- **6 month** Year 7-8 science teacher secondment to Scion

www.scionresearch.com/ar15futurescientists

Outreach

54

Gallipoli pines raised and donated to RSAs for Gallipoli Centenary

- **47,078** unique visitors to our website
- **7,005** views on YouTube
- **1,375** followers on LinkedIn
- **1,073** subscribers to *Scion Connections*

www.scionresearch.com/ar15outreach

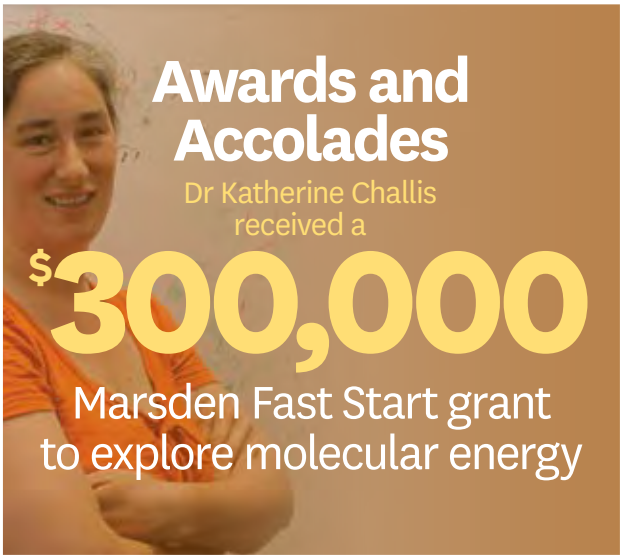
Publications

126

scientific papers published

- **53.6** average weighted value of publications
- **7.66** citations per paper
- **40** papers published in Vol 44 *New Zealand Journal of Forestry Science* plus supplement

www.scionresearch.com/ar15techtranslation



Awards and Accolades

Dr Katherine Challis received a

$300,000

Marsden Fast Start grant to explore molecular energy

- **14** other scientists received grants to further their research
- **8** scientists appointed to national and international professional bodies

www.scionresearch.com/ar15achievements

Research collaborations

Scion's networks extend around the globe. Over the years, our scientists have developed strong international and national linkages with universities and other research institutes with the common goal of extending scientific knowledge and developing innovative technologies to overcome some of the many and complex challenges facing today's societies.

Such collaborations keep our scientists at the forefront of scientific achievement and technological advances, and help to make Scion an attractive career destination for leading international scientists.

Overseas collaborations

A collaboration agreement between Scion and VITO (Belgium) will see both organisations explore exciting opportunities to exploit lignin. The project will involve separating Scion's lignin hydrogenolysis oils with VITO technologies, with both organisations able to explore the development of new products using these.

The Scion side of the collaboration is led by Dr Kirk Torr (below right) with the support of Dr Florian Graichen who recently joined Scion from VITO.

A joint proposal with FPInnovations (Canada) was submitted to Forest and Wood Products Australia Ltd (FWPA) for assessing wood processing options for different regions in Australia. A review of wood modification technologies was conducted for FWPA and a webinar given to present the technology options.

A joint work plan between Scion and VTT in Finland will involve a jointly funded postdoctoral project to investigate either bark biorefinery or food from wood. This project fits current Scion initiatives and will speed up progress. Other projects include Scion adapting VTT's hemicellulose technology, which is used to make new packaging products, to radiata pine in New Zealand.

Collaborating at home

Our Forest Genetics Team continues to team up with the Radiata Pine Breeding Company (RPBC) and Scion's Forest Protection Team to screen the next tranche of RPBC's elite germplasm for resistance to red needle cast. Preliminary results indicate that genetic variation does exist, and some initial 'resistant' and 'susceptible' genotypes have been identified for further validation. These genotypes will be used in the MBIE Healthy Trees, Healthy Future (HTHF) programme.

We continue to collaborate with AgResearch under its MBIE Enabling Technologies programme for next generation sequencing and genotyping in species other than radiata pine.

An MBIE contract is in place to further investigate industrial symbiosis with the first partner meetings held. The initial focus is on gathering the dataset to use the Kawerau and Fonterra case studies as a model. Scion has helped with the commissioning of the new bark briquette plant as part of the industrial symbiosis complex at Kawerau.

As part of our commitment to the Bioresource Processing Alliance (BPA), a hydrothermal project on wool carpets with AgResearch is complete, showing good potential to develop an alternative to landfill and the possible development of new IP.

Dr Daniel Gapes has developed a strategy for our engagement with BPA, identifying Scion-led projects for: the development of slow release fertiliser from lignin; extracting and modifying sawdust for the animal and pet food industry; cross sector resource/value chain analysis systems; and biopolymer production from low-value resources.

More examples of our research collaborations are found at www.scionresearch.com/ar15collaborations
www.scionresearch.com/scionvito

Financial results summary

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

EBIT: Earnings before interest, tax and restructuring costs.

EBIT Margin: EBIT ÷ revenue.

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

EBIT-R Margin: EBIT-R ÷ revenue.

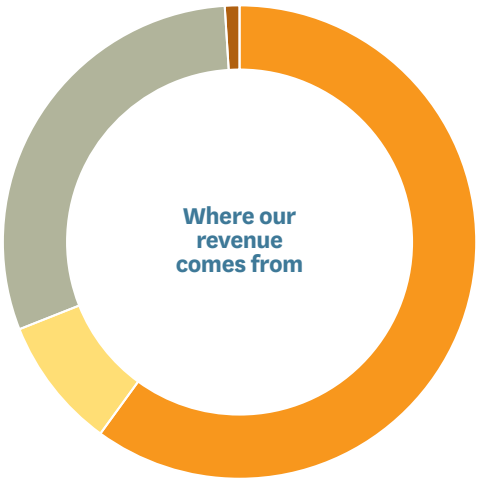
Return on equity: Net profit after tax ÷ average shareholders' funds, expressed as a percentage.

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

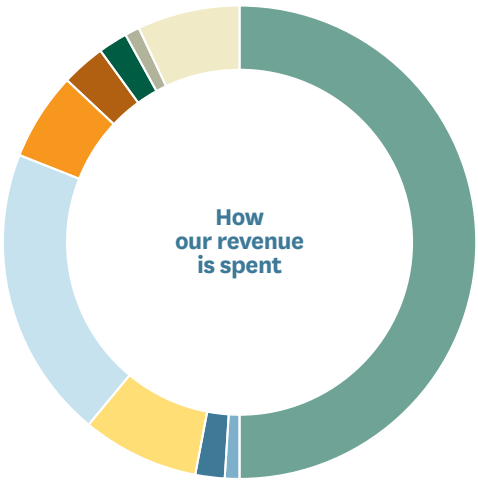
Gearing: Financial debt ÷ financial debt plus shareholders' funds.

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

	2013 Actual	2014 Actual	2015 Budget	2015 Actual
Revenue, $m	45.49	48.14	49.12	47.34
EBIT, $m	2.55	4.28	2.50	3.27
EBIT Margin	5.6%	8.9%	5.1%	6.9%
EBIT-R, $m	3.52	5.03	3.53	4.07
EBIT-R Margin	7.7%	10.5%	7.2%	8.6%
Total Assets, $m	41.52	43.70	45.09	46.31
Return on Equity	5.8%	9.4%	5.6%	7.3%
Equity Ratio	69.6%	72.0%	72.1%	74.1%
Dividend, $m	-	-	-	-
Gearing	0.0%	0.0%	0.0%	0.0%



60% Ministry of Business, Innovation and Employment
9% Government department
30% Other commercial
1% Interest



50% Employee remuneration
1% Training and recruitment
2% Consumables
8% Depreciation and amortisation
20% External services and contractors
6% Premises costs
3% Travel
2% Other operating costs
1% Non operating costs
7% Net profit before tax

Glossary

BOPRC	Bay of Plenty Regional Council
BPA	Bioresource Processing Alliance
BPN	Biopolymer Network Ltd
CHH	Carter Holt Harvey
CRI	Crown research institute
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
DNA	Deoxyribonucleic acid, genetic hereditary material
DOC	Department of Conversation
EPA	Environmental Protection Authority
EU	European Union
FFR	Future Forests Research Ltd
FGLT	Forest Growers Levy Trust
FIF	Forest Investment Finder
FSC	Forest Stewardship Council
GCFF	Growing Confidence in Forestry's Future research programme
GM	Genetic modification
LGNZ	Local Government New Zealand
LiDAR	Light detection and ranging
MBIE	Ministry of Business, Innovation and Employment
MfE	Ministry for the Environment
MKRFA	Marlborough/Kaikoura Rural Fire Authority
MPI	Ministry for Primary Industries
NRFA	National Rural Fire Authority
NTWG	Northern Tōtara Working Group
NuBalM	Scion's Nutrient Balance Model
NZFOA	New Zealand Forest Owners Association
NZFS	New Zealand Fire Service
PGP	Primary Growth Partnership
PSAF	Pre-Seed Accelerator Fund
PwC	Pricewaterhouse Coopers
RLC	Rotorua Lakes Council
RPBC	Radiata Pine Breeding Company
Scion Core	Scion Core Funding
SFF	Sustainable Farming Fund
STFMP	Strategic Tactical Fire Management Planning
STIMBR	Stakeholders in Methyl Bromide Reduction
SWI	Solid Wood Innovation
TTT	Tane's Tree Trust
UAV	Unmanned aerial vehicle
UNFCCC	United Nations Framework Convention on Climate Change

Collaborators Investment Website YouTube

Scion Chair Tony Nowell CNZM *(left)* and Directors
Sheldon Drummond, Judith Stanway and Elizabeth Chambers *(in front)*.

The Directors' Report is available in Part B of this Annual Report on
our website www.scionresearch.com/annualreports


SCION
forests • products • innovation