



Erosion over many years has resulted in high sediment loading of rivers in the Waiapu Catchment.

Healthy land, healthy rivers, healthy people

A unique Memorandum of Understanding signed last year between the Ministry for Primary Industries, Te Runanga o Ngāti Porou (TRONPnui) and Gisborne District Council (GDC) has marked the beginning of a long journey to restore the health of the Waiapu Catchment. The catchment, situated on New Zealand’s East Coast, is struggling to overcome years of landscape degradation, poverty and climate change, compromising the ability of local people to revitalise their existing way of life.

At the heart of the MoU is research undertaken by Scion’s Forest Systems Team, expanding on work they did in 2012 to explore the factors contributing to this decline. Both projects are now deeply embedded in the relationship between the Crown and Ngāti Porou in an historic 100 year Waiapu Restoration Partnership formed to restore the health of the land, the river and its people in what is widely acknowledged to be a complex and inter-generational process.

“Communities in the catchment and Ngāti Porou in particular, have been dealing

with the effects of environmental, social and economic shock for over a century,” says team manager and project leader Tim Barnard. “Heavy deforestation has led to years of erosion, and the Waiapu River has the highest level of sediment loading of any river in the country. The flow on effect for the community is huge with many people leaving the area to seek opportunities for a better future, elsewhere.

“Without intervention, the social, economic and biophysical factors that have contributed to the present state of the catchment will continue into the future, and climate change is expected to add further stressors.”

As Tim explains, the leadership of change rests within the community itself, and the governance of Ngāti Porou. “To improve the resilience of the catchment to further shock, the future must be built on the strengths of the community and its current realities and resources. Partnerships with external agencies will also play an important

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Growing a resilient bioeconomy

Land, water and trees are among New Zealand's most valuable assets. With the world's population projected to reach 9 billion by 2050, it does not take much pondering to realise the value of these assets will continue to increase.

More people and wealth means up to 70% more food and at least three times more wood fibre demand compared to now, will be required. A corollary will be increased effort to introduce synthetic substitutes, such as meat and milk with negligible environmental footprints, to consumers. And, as a 2013 United Kingdom foresight exercise on the future of manufacturing¹ highlighted, steps to reduce food, fibre and other waste along the supply chain will also intensify.

In parallel, the natural limits of ecosystems and climate change, and the changing consumer and community expectations of environmental quality, are restraining options to intensify land use. Investment in science and innovation to address these restraints to economic growth through, for example, increased efficiency of land, nutrients, water and carbon, is imperative for New Zealand primary sectors to remain export competitive and able to access markets. However, given our relatively modest volumes of production, these steps need to be complemented by a redoubling of effort to add value (margin) in the supply chain in order that returns to land owners are increased (and hopefully not as readily capitalised into land values as in the past).

It is inevitable that these strategic drivers will also precipitate land-use change to lower nutrient leaching options such as forestry, and that this will be necessary at a reasonably significant scale in water and lake catchments with low and deteriorating water quality.

This strategic context is not novel - it is well documented², evidence-based and makes it abundantly clear what Scion needs to do to help all aspects of the New Zealand forest industry and bioeconomy to prosper. We must:

- make plantation forests more productive (at least twice), increase uniformity within and between trees, and reduce costs in the supply chain through automation, traceability and robots;

- ensure access and licence to operate with the latest genetic improvement and other forest productivity enhancing and protection technologies;
- recognise and monetise the forest ecosystem services to ensure best, and long-term sustainable use of land and water, and resilient regional economies;
- generate value from as much of the tree as possible, including bark and some of the harvesting residues presently left in the forest;
- exploit the opportunities that the global transition to a 'low carbon' bioeconomy present through renewable packaging, lightweight materials, and chemical, energy and other industrial bioproducts derived from wood fibre and forest biomass;
- increase the use of wood in both residential and commercial construction by engineering and modifying solid wood; industrialising building (e.g. prefabrication) processes and ensuring the respective environmental credentials of wood and competing building solutions are well-understood; and,
- adapt and co-develop technologies such as 3-D printing (additive manufacturing), remote sensing and robots that can improve the competitiveness of small-to mid-scale companies.

Our approach to all of these areas of science are set out in Scion's recently approved **2015-2020 Statement of Corporate Intent**, which is available on our website along with information about our staff, equipment and other capabilities, and previous editions of *Scion Connections*.

As always, I and the people named at the end of each article, welcome any feedback and comments on the articles in this issue of *Scion Connections*. I particularly encourage you to take note of our involvement in the most recently launched National Science Challenge Science for Technological Innovation, and our leading edge work in 3-D printing (see page 7).



Dr Warren Parker,
Chief Executive



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¹ Foresight project looking at the long-term picture for the UK manufacturing sector between now and 2050; <https://www.gov.uk/government/collections/future-of-manufacturing>

² See for example, Proudfoot, I. 2014. Growing Value, KPMG Agribusiness Agenda, Volume 1; available from <http://www.kpmg.com/NZ/en/IssuesAndInsights/ArticlesPublications/agribusiness-agenda/Documents/KPMG-Agribusiness-Agenda-2015-vol1-Growing-Value.pdf>

Urgent need for global strategies on forest health

Keeping invasive pests out of forests should be a top priority for all countries according to Scion Principal Scientist, Dr Eckehard (Ecki) Brockerhoff.

Ecki is co-author of a review on global biosecurity published recently in the prestigious journal, *Science*. In the review, Ecki and his co-authors from the University of Pretoria, stress the need for urgency in developing a global strategy to deal with pests in planted forests.

"Forests worldwide are continually under threat from introduced insects and pathogens despite the best biosecurity efforts," he says. "Without a concerted global effort to understand and control invasive pests, the problem will worsen as international trade increases.

"Planted forests of radiata pine have been successful partly because the trees have been separated from their natural pests. This also makes them vulnerable if these pests accidentally arrive, or if trees encounter new pests for which they have no resistance.

"Keeping forests secure relies on quarantine, treatment of imported goods, and monitoring insect traps and trees around ports and other high risk sites. When these biosecurity measures are applied strictly, they work very well. New Zealand has some of the best practices in the world.

"But biosecurity is only as strong as its weakest link. Many countries don't have the resources to put biosecurity measures in place, and once a pest becomes established, it can be impossible to eradicate. The pest can use the new country as a stepping stone for further invasions."

Over and above a forest's ability to regulate climate, store carbon, prevent erosion and improve water and air quality, the planted forestry industry is New Zealand's third largest export earner, contributing

around \$5 billion a year to the economy. Ecki says the future of planted forests will be influenced by our ability to respond to damaging pests and the threat of biological invasions. He goes on to say that **the only way we can realistically deal with tree pests will be through global collaborations, and the sharing of experience and research findings.**



"Single country strategies won't be sufficient as the threats to both planted and indigenous forests increase worldwide. And it's also unlikely that poorer countries can afford to maintain the level of biosecurity needed for total exclusion. A good example is the introduction of myrtle rust, caused by *Puccinia psidii*, into Australia despite considerable knowledge of the pathogen, and Australia

having some of the best phytosanitary measures in place as well as the benefit of relative geographical isolation. We are now working closely with our Australian counterparts to prepare for a possible incursion of the pathogen here."

Preparing for future invasions is not simply recognising there is a problem, but also investing in research and innovation. Our scientists, and those at other organisations here and overseas, are using techniques such as biological control - introducing natural predators, and knowledge of tree genetics and forest ecosystems to develop non-chemical methods for controlling existing pests and preparing for future threats.

"We have excellent systems in place to prevent the arrival of forest pests and diseases, to respond to incursions and to manage those that do become established," says Ecki. "But while institutions like the International Union of Forest Research Organizations (IUFRO) help facilitate collaboration, there is no single body or funding structure to support a global strategy for dealing with pests in planted forests."

According to Ecki, now is the right time to talk about this issue with one of the focus areas of this year's World Forestry Congress of the Food and Agriculture Organisation for the United Nations having been on forest health and sustainability.

He stresses that with increasing globalisation and international trade, it is important for New Zealand to maintain strong international networks to address the biosecurity challenge collectively and, through science partnerships, help countries that may not have the resources or expertise to put biosecurity measures in place.

For further information

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Healthy land, healthy rivers, healthy people

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role in bringing additional knowledge and resources into the community."

The afforestation of highly erodible land using conventional radiata pine forestry will be high priority for the partnership, but it is expected new forestry models and diverse land use will play a major role in building community resilience and cultural sustainability for the future. To

achieve this in an holistic way and one which is culturally relevant, says Tim, requires a level of political sophistication that arguably has not yet been achieved anywhere in New Zealand.

At the final hui of the project in Gisborne, Scion's final research report was welcomed by MPI, TRONPnui and GDC, being cited as an exemplar for future engagement with Māori. The restoration partnership adopted many of the recommendations of Scion's earlier work done in 2012, and **won the MPI Director General's Award for Partnership this year.**

According to Ngāti Porou researcher, Tui Warmenhoven, "This research project is a model for other New Zealand communities of how science and Mātauranga Māori can be integrated to bring about meaningful relationship building, stakeholder commitment and pathways to ongoing research, partnership and progress."

For further information

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Celebrating the year's achievements

The past financial year has been jam-packed with the development of clever gadgets to measure wood quality, exciting scientific discoveries of valuable chemicals hiding in bark and other tree tissues, and the arrival of new expertise in the areas of human factors, biotransformation and clean technologies.

Research indicates that the future will increasingly be driven by the need to address environmental restraints such as water quality and climate change; and that forestry will expand to meet this demand with a greater emphasis on integrated land use that will lead to more forest derived products in supply chains, and regional job creation. We've been working hard on a range of projects to increase the profitability of the forestry industry and expand its potential as a versatile building block of the future. Here are some of our achievements this year:



Developing new industries for Northland

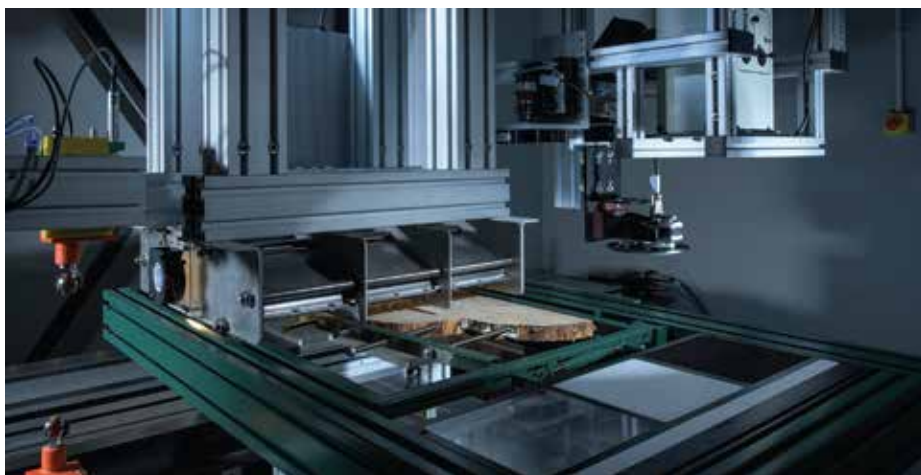
We have been working with several organisations to explore the feasibility of a new industry based on Northland's extensive tōtara resources, which could add another dimension to the forest products industry and the regional economy. Studies

indicate there may be over 200,000 hectares of naturally regenerated tōtara growing on private land in the region.

"Tōtara is a resilient species that grows vigorously in various soil types under a variety of conditions," says indigenous forest specialist Greg Steward. "Until recently, tōtara has been considered of little economic value, however it produces attractive, straight grained wood and durable heartwood that is inherently resistant to fungal degradation."

"Northland could really benefit from a new wood products industry based on this resource. The development of high-value wood products to replace imported products would see the generation of new business opportunities along the value chain, as well as the commercial investment in a culturally important indigenous species."

Greg says that while the growth rate of tōtara is unlikely to reach that of fast growing exotics such as radiata pine, our scientists are confident there is an opportunity to increase productivity of the species.



Boosting forestry productivity

Scion is in its second year of the 6-year Growing Confidence in Forestry's Future programme, a joint programme between industry, Scion and MBIE aimed at boosting the productivity and economics of forestry. Our scientists have already made a number of important achievements, particularly in calculating the gap that exists between current and potential productivity.

"We're using a combination of modelling studies and historical data to examine ways in which forest growers can increase productivity in a sustainable manner without compromising wood quality," says science leader Dr Peter Clinton. "The programme is building on the legacy of trials and growth monitoring plots, some of which were established almost 40 years ago, to study the effects of factors such

as silviculture, genetics, nutrition and site disturbance on tree growth and wood properties.

"Recent data from these historic trials have provided new insights into the drivers of productivity, and the impacts of forest management activities on wood quality and sustainability. This information is already helping forest growers better understand the existing forest resource and to develop management regimes for stands that are being replanted."

New information on the internal characteristics of trees will soon be available through Scion's purpose-built robotic disc scanner (see page 7). It will enable us to better understand the variability in wood properties that exists within and between trees, and the consequences of this variation on end products such as sawn timber.



Forests provide more value than timber and wood fibre

There is a growing realisation of the environmental and social benefits provided by forests over and above timber and wood products, including those relating to climate change.

“This year, our research team has made strides in evaluating ecosystem services, such as carbon sequestration, water quality improvement, avoided erosion and increased biodiversity,” says resource economist Dr Richard Yao. “In a recent catchment-level study, we showed that converting 320 hectares of dry stock farms to exotic forestry could provide a

net gain in the value of ecosystem services of about \$9,000 per hectare per year. This would add almost \$3 million to the ecosystem services value of the catchment.

“The development of methods to estimate the non-market value of ecosystem services, such as recreational walking and biodiversity, means these services can now be better represented in land management discussions alongside those with market values.

“This provides a comprehensive framework for council land managers that will ensure the full potential of their catchments are achieved in the long term.”

The ultimate biorefineries

Our researchers are making some unexpected discoveries about bark and other tree tissues. Scion's transformative wood dewatering technology is used to extract water and bio-chemicals from radiata pine to produce high-value, modified wood products. **We recently branched out into other species, and other parts of the tree that traditionally go to waste - such as bark, leaves and needles,** using a similar technology.

“The results have been surprising, and very exciting,” says research leader Dr Stefan Hill, who has been using nuclear magnetic resonance and other analytical techniques to test the chemical make-up of the extractives recovered.

“We identified a group of highly functional chemicals that were previously not easily obtainable. With a high percentage of bark and other tissue being burned or dumped, this means valuable chemicals are currently going to waste.

“These discoveries offer exciting possibilities for future ‘whole-of-tree biorefining’ where virtually none of the tree is left behind in the forest and a tree’s entire resources are more fully utilised.”



Easier to process softwood

Scion's wide research brief takes it well beyond tree growing. Biotransformation is ground breaking work, and Scion scientists teamed up with the University of Wisconsin-Madison to make radiata pine and other softwoods easier to process into valuable feedstock for the pulp, paper and biofuel industries.

Metabolic engineering allows biotechnologists to introduce a desirable new pathway or trait into a population where it is not normally, or readily available. In this case, our scientists have shown it's possible that we can engineer softwoods, such as radiata pine, to produce easier to process hardwood-like lignin while retaining their outstanding fibre properties.

“Easier to process softwood has both economic and environmental benefits,” says research leader Dr Glenn Thorlby. “Needing less energy, the pre-treatment process will be faster, more efficient and less wasteful, yielding improved feedstock for pulp, paper and biofuel industries.”



Achieving environmental equilibrium with timber

Scion's Built Environment Team has developed a strategy to address climate change by using timber-based building materials. Urban Equilibrium aims to maintain the balance between humanity and the natural environment by using building materials that sequester and store carbon, and help reduce greenhouse gas emissions.

“With the move to more, and larger cities, it's becoming more important for the built environment to balance its greenhouse gas emissions,” says sustainable architect Andrea Stocchero. “We can calculate the amount of carbon sequestered within the built environment starting with the volume of timber used in solid timber buildings.

“As an exemplar, we applied the principles of urban equilibrium using solid and engineered wood construction technologies, to Auckland's forecast urban development over the next 30 years. This demonstrated that **Auckland Council could achieve their carbon emissions reduction target 25 per cent faster than planned.**”

You can read more about our achievements in Scion's 2015 Annual Report Highlights, to be published in early October, at www.scionresearch.com/annualreports



Bronze bust of philosopher Karl Marx in Chemnitz, one of the cities visited in Germany.

Forging closer ties with Germany

An exploratory visit to Germany earlier this year by scientists from our Manufacturing and Bioproducts group has laid the foundations for what could become a valuable network of new research collaborations for the development of bioproducts.

The visit follows on the heels of a study tour visit to Scion, made in February, by a delegation of scientists under the FRIENZ ‘Factories of the Future’ initiative, which facilitates research and innovation between Europe and New Zealand.

Scion’s team focused their visits on German institutes involved in research to grow the global bioeconomy, specifically in the areas of biotechnologies, bioenergy, biochemical and biorefinery research.

“We came away with a much greater understanding of the German science environment,” says Dr Gareth Lloyd-Jones, science leader for biotransformation. “Being able to tour these facilities and talk with scientists directly has helped us identify individuals and regional clusters of research organisations with whom we could make valuable scientific collaborations.

“Germany tends to establish virtual research clusters with quite a bit of overlap between them. This means that **our participation in relevant clusters would provide Scion with excellent future networking opportunities** and a means to explore exchange visits with researchers and companies, and possible joint

developments. It would also provide us with access to leading research infrastructure such as biorefinery pilot scale plants and agricultural sites.”

Dr Paul Bennett, science leader for clean technologies agrees. “The institutions we visited all had world class capability and facilities, particularly at pilot scale, and most of them were keen to explore possible collaborations with New Zealand.

“Germany is very active in general bioenergy and biorefinery research. The different research groups involved seemed to be well connected and have a good understanding of what other groups were doing within Germany. One common feature was the use of large flexible work spaces for their laboratory and pilot equipment.”

The team came away with a good possibility for **collaborative work in carbon fibres and bioadhesives from lignin** with one of the universities, which in turn would provide our scientists with access to their large scale processing equipment. Other possibilities also exist in thermochemical processing and biofuels research.

General Manager Manufacturing and Bioproducts Dr Elspeth MacRae says the

visits are already yielding dividends, with return visits to key institutes in the lower Saxony region planned for October.

“Research institutes within this cluster, particularly Chemnitz University of Technology, align well with Scion’s focus in engineered wood and wood-fibre products, 3D printing, bioproducts and renewable chemicals, and packaging. We also want to explore possible bioenergy and biofuels research with Aachen University and the Karlsruhe Institute of Technology.

“The institutions we visited all had world class capability and facilities, particularly at pilot scale, and most of them were keen to explore possible collaborations with New Zealand.”

“We have already applied to the Federal Ministry of Education and Research in Germany and the Royal Society for funding to consolidate our interaction with the Saxony cluster and grow joint activities. Other one-on-one relationships are also underway.”

This study tour was funded by the Royal Society of New Zealand and MBIE.

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Forester of the year

In recognition of his contribution to the forestry sector, Dr Brian Richardson, Scion's general manager forest science, was recently presented with the New Zealand Institute of Forestry (NZIF) Forester of the Year Award.

"The announcement came as a complete shock," says Brian. "I didn't know I'd been nominated. I was sitting at the awards dinner hearing the presenter describe the award recipient, and thinking, gee he sounds familiar."

The award recognises leadership, excellence and personal integrity, particularly where this demonstrates the character and strength of the forestry profession.

Brian has been with Scion for over 30 years, since Scion was part of the New Zealand Forest Service and known as the Forest Research Institute and before it was established as a Crown research institute. In that time he has seen some significant changes.

"Probably the biggest change that's happened in my time, was when the New Zealand Forest Service was abolished in the late '80s. Indigenous forests were handed to the newly formed DOC and a lot of the Crown planted forests were sold to the private sector.

"There's more transformation to come with forestry well positioned to take advantage of forecast global fibre shortages, to underpin regional development and support climate change mitigation strategies, and a perfect complement to reduce the environmental footprint from other productive sectors."

Brian is the third scientist from Scion to receive the Forester of the Year award. Former staffers John Balneaves and David Bergin have received the accolade. Former staffer Bruce Manley received the award before he was at Scion, and former Scion board member Peter Berg is also a recipient.

For further information

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Meet DiscBot, our new wood quality detective

Developed and built in-house, Scion's new 'DiscBot' is a novel scanning technology designed to assess a range of wood properties that affect the quality of sawn timber and other end products. The automated disc scanner uses a robot to move wood discs past different sensors, which capture information on wood density, microfibril angle, chemical composition and spiral grain angle.

A near infrared camera is used to detect the different light absorbing qualities of lignin, cellulose and other chemicals in the wood. Wood density is measured using X-rays, and stiffness by the speed at which an ultrasound wave travels through the wood. Masked light transmission is used to detect the presence of spiral grain by measuring how light is distorted as it travels through the wood.

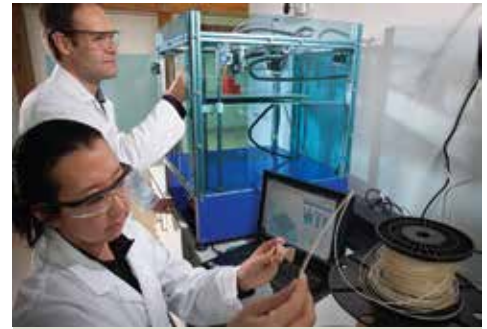


"As far as we're aware, this technology is unique," says wood quality scientist, John Lee. "The DiscBot will enable us to understand the quality of wood that's been laid down throughout the whole tree, how this is affected by genetics, silviculture and site, and the implications for end product quality. This knowledge will help us better characterise the forest resource out there, so we can look at how we can best add value to it.

"Historically, we've measured wood properties on core samples taken from one or more heights in a tree, which gives us limited understanding of the variation in wood properties within a tree. The DiscBot can test multiple discs quickly and efficiently, to provide a more complete picture of the full extent of variation that exists. The volume and speed of data generated will be invaluable for our more expansive projects like the Growing Confidence in Forestry's Future programme, and for our commercial clients."

For further information

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Reconstructing biomass by 3D printing at Scion

An investment in 3D printing technologies enables Scion to develop a range of new bioplastics for use in these technologies, such as filaments (thin strands of material), powders and fibre reinforced filaments.

"As part of the Extrusion PLUS project, we are developing products with advanced functionalities from lignocellulosic biopolymers and bioplastics," says Dr Florian Graichen, science leader for biopolymers and chemicals. "Our challenge now is to work with these biopolymers to formulate bioplastics suitable for use in 3D printing. This would enable a vast range of products from machine componentry to large-scale construction materials to be manufactured from renewable biomaterials with low environmental impacts.

"New ways of processing biomaterials will reduce our reliance on imported raw materials. It will also see more value generated from trees by making better use of lignocellulosic biomass, such as wood processing residues."

Alongside a role at the head of Portfolio 5 in the recently launched Science for Technological Innovation National Science Challenge, these capabilities have Scion fronting its spearhead project. This will see biopolymers and biofibres from plants and animals formulated by a pan organisational team into advanced biomaterials for 3D printing, targeted at applications of value for New Zealand.

"This project will help overcome key hurdles in using blends of biopolymers and biofibres in manufacturing, and facilitate the design of equipment suitable for processing these materials," says Florian. "It will fast track the commercialisation of highly functional 'green' products using local, renewable materials, which will have an impact on the whole economy."

For further information

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Fond farewell to Paul Kibblewhite

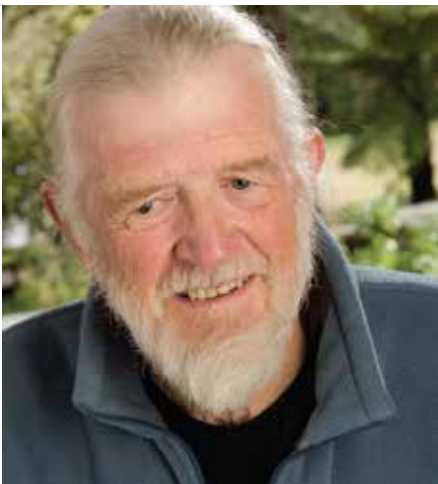
Scion staff bid a fond farewell to Paul Kibblewhite in August. Paul was a well-respected, long-time scientist at Scion known as much for his large personality as he was for his expertise and international standing in wood fibre and pulp sciences.

Paul joined the Forest Research Institute (as Scion was called then) in 1969, as a wood chemist. He quickly developed a profound knowledge of papermaking fibres and pulps, and by the early 1980s, was regarded as the leading scientist in the world in wood fibre science. His major contribution was to our understanding the importance of fibre classes, and the variability of properties based on location within trees, genotypes, site and environment.

Paul led the FRI Fibre Research Team that played a major role in supporting the developing New Zealand pulp and paper industry as it established itself as a producer of quality paper to at least equal that of the Northern Hemisphere. He published widely, and was frequently invited to present seminars and workshops all around the world.

In 1993, Paul was made a Member of the British Empire in recognition for his contribution to science. He was also a Fellow of the Royal Society of New Zealand and winner of Appita's most prestigious award, the LR Benjamin Medal.

Paul's deteriorating eyesight meant that in time, he was accompanied by a series of guide dogs. This did not stop him from pursuing his love of science and outdoor pursuits, particularly hiking. Following a dramatic helicopter rescue of guide dog Taupo when he was accidentally poisoned on a three day tramp in Tongariro National Park, Paul and Taupo successfully repeated the exercise some time later. The headlines read "Paul and Taupo knocked Tongariro off".



Forest Genetics for Productivity Conference: the next generation

14-18 March 2016. Rotorua Energy Events Centre, Rotorua.

This conference is part of the International Union of Forest Research Organization's (IUFRO) calendar of events, and is expected to attract around 200 delegates from all over the world. Registrations are now open.

Science leader for forest genetics and conference convener, Dr Heidi Dungey, says she is excited to be bringing a conference of this calibre to Rotorua, and that it has attracted keynote speakers who are internationally renowned.

"Our theme is 'The next generation' and we are putting together a stimulating programme that will include open dialogue on how to maximise productivity as well

as the application of new technologies, such as genomics and remote sensing."

Conference research topics include breeding productive and resilient forests, finding the synergies in genotype, environment and silviculture, and genomics and phenomics.

Confirmed keynote speakers are Professor Brian Cullis (Australia), Professor Dario Grattapaglia (Brazil), Dr Antoine Kremer (France), Professor Dr Ulrich Schurr (Germany), Dr Jerry Tuskan (USA) and John McEwan, (New Zealand).

The Radiata Pine Breeding Company is the platinum sponsor; other sponsorship opportunities are available.

www.fgpc2016.nz/fgp16

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