



Photo: Port of Tauranga.

Urgent need for a global strategy on forest health

A review of global biosecurity undertaken by Scion Principal Scientist Dr Eckehard (Ecki) Brockerhoff and colleagues from the University of Pretoria highlights the urgent need for a global biosecurity strategy for planted forests. The review¹ was published recently in the prestigious journal 'Science'.

"Forests worldwide are continually under threat from introduced insects and pathogens. Without a concerted global effort to control invasive pests, the problem will worsen as international trade increases," explains Ecki. "Planted radiata pine forests 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 the 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. New Zealand has some of the best

biosecurity practices in the world but many other countries don't maintain highly effective systems. Once a pest becomes established somewhere, it can be impossible to eradicate and can use the new country as a stepping stone for further invasions."

Ecki says the future of planted forests will be influenced by our ability to respond to damaging pests and the threat of biological invasions. The only way we can realistically deal with this will be through global collaborations, and the sharing of experience and research.

"Single-country strategies won't be sufficient as the threats to planted and indigenous forests increase worldwide and it is unlikely that poorer countries can afford to maintain the level of biosecurity needed for total exclusion."

Preparing for future invasions will require investment in research and innovation. Scientists in New Zealand and overseas

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¹ Wingfield, M. J., Brockerhoff, E. G., Wingfield, B. D., & Slippers, B. (2015). Planted forest health: The need for a global strategy. *Science*, 349, 832-836.

Paris Climate Agreement and current forest plantings don't add up

On 12 December 2015, 196 countries agreed terms for a legally binding Paris Climate Agreement¹. The agreement will come into force on 22 April 2016 if 55 countries, comprising at least 55% of global emissions, ratify it. Initially, there was little optimism that an agreement could be brokered; the fact one was, illustrates how concerned governments, business and non-government agencies are about the effects of rising global temperatures.

Key aspirations of the agreement include:

- holding the increase in the global average temperature to below 2°C above pre-industrial levels, and endeavouring to limit it to 1.5°C
- for parties to reach global peaking of GHG emissions as soon as possible and undertake rapid reductions thereafter
- each party to prepare and maintain successive Nationally Determined Contributions (NDCs) that it intends to achieve
- parties formulate long-term low GHG emission development strategies that account for individual national circumstances
- parties communicate their NDCs with clarity, transparency and understanding.

New Zealand's NDC is to reduce national 2005 GHG emissions by 30% by 2030, or about 11% below 1990 levels.

Greater emission reduction efforts will be required to achieve these objectives than those associated with the Intended Nationally Determined Contributions (INDCs) stated in the Draft Agreement. Furthermore, parties to the agreement whose INDC has a time frame of 2030, will be required to communicate or update these contributions by 2020, and do so every five years. This is important stuff for signatory countries!

Figures released recently by the Ministry for Primary Industries showed only 3,000 hectares of new forest were planted in 2015, and the total area of planted forest fell by 16,000 hectares². About 1,000 tonnes CO₂e per hectare are stored in a mid-rotation radiata pine forest, therefore deforestation adds to New Zealand's greenhouse gas reduction target. But with agriculture contributing 49% of total emissions, and currently outside the Emissions Trading Scheme (ETS), deforestation effects must be bolstered by the transport and energy sectors, or by buying offshore carbon credits.

Scion recently investigated whether forests converted to dairying in the central North Island would increase export earnings³. Using average prices for the 10 year period to 2014/15, and an area of 28,000 hectares, we estimated manufactured exports to be \$161 million per annum for forestry and \$193 million for dairy (including meat).

However, this difference was minimised by the cost of GHG emissions and leached nitrogen (up to \$31 million credit to forestry and up to \$18 million cost by dairy).

The point to consider is that smart economic growth should account for environmental and social considerations to get the best long-term national outcome. Furthermore, land-use decisions should ideally optimise the respective strengths and weaknesses of particular enterprises, for example livestock produce emissions; forests sequester carbon dioxide and leach little nitrate in waterways.

I, and others⁴, have written previously that an ETS carbon price around \$12-15/tonne CO₂e will incentivise plantation and permanent forest plantings. Scion's modelling indicates that if the maximum afforestation rate achieved during the 1990s was sustained until 2030, just over 1 million hectares of new planted forest could be established, with modest effect on food production if this was on currently under-utilised Māori land. Sequestration by these new forests in 2030 would be 23.6 Mt CO₂e, offsetting 52% of non-agricultural emissions or 28% of total emissions in 2030. Forest biomass could also play a major role in reducing emissions from industrial heating and increase New Zealand's energy security.

A major co-benefit of tree planting will be increased log (wood fibre) security for wood processors. Northland wood processors recently lamented their inability to source suitable quality logs. It will be much tougher for them in the early 2030s unless deforested land is replanted, and new areas are forested, from this winter.

If the total area of forested land is increased, New Zealand has a good chance of meeting its 2030 NDC. Water quality would improve, biodiversity increase, extra Māori land would be generating wealth, livestock farmers' nutrient limits could be less onerous, mill owners would be happier and export earnings would likely not be less than those otherwise earned from livestock. This seems a good formula to me!

I welcome your comments on this topic or any of the other articles in this edition of *Scion Connections*.



Warren Parker

Dr Warren Parker,
Chief Executive

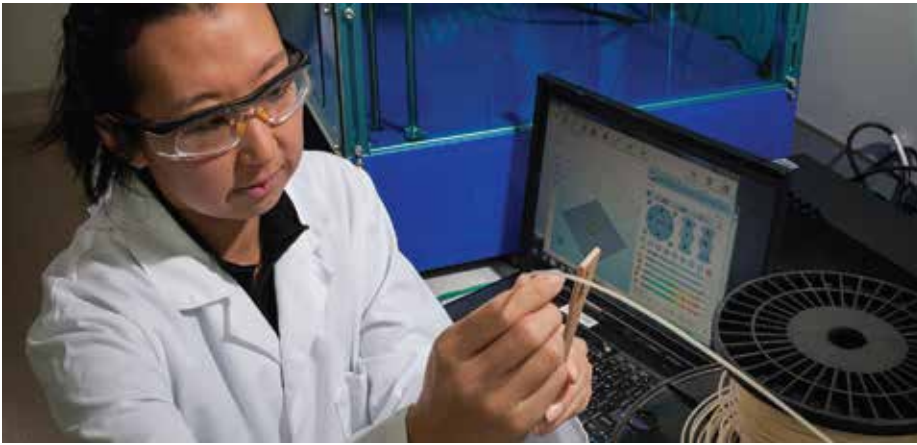
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¹ See <https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf>

² See <http://www.nzfoa.org.nz/news/foa-news/foa-media-releases-2016/1520-230216foanews>

³ Monge, J.; Velarde, S.; Yao, R.; and Pizzirani, S. 2015. Identifying Complementarities for the Dairy and Forestry Industries in the Central North Island. Scion report to Oji Fibre Solutions and Waikato Regional Council (October).

⁴ Clark, P. Forestry and the Emissions Trading Scheme, Wood Matters, December 2015, <http://nz.pfolsen.com/market-info-news/wood-matters/2016/february/forestry-and-the-emissions-trading-scheme/>



Dr Marie Joo Le Guen examining bio-based filament for 3D printing.

Fund is catalyst for international collaborations

An exploratory visit to Europe last year by scientists in our Manufacturing and Bioproducts Group is already paying dividends for at least two scientists.

Drs Stefan Hill and Marie Joo Le Guen have both been awarded funding through MBIE's new Catalyst Fund to develop global strategic partnerships that support high-quality research of benefit to New Zealand. The fund aims to strengthen our links with world-class international research groups, infrastructure and initiatives.

Marie Joo has received \$150,000 to develop an innovative 3D printing system that uses sustainable feedstocks, in collaboration with AUT and Chemnitz University of Technology in Germany.

"Our focus will be on using materials sourced from primary industry waste, such as wood and sea shells."

"The development of 3D printing has allowed us to produce objects that have never before been possible with traditional manufacturing techniques, creating new market opportunities," says Marie Joo. "This funding will enable us to develop a 3D printing method that uses bio-based materials, particularly by-products from primary industries that are cheap and readily available."

Natural resources are not consistent, Marie Joo explains, and Scion has already demonstrated that bio-based materials require specific handling and modification to be suited for 3D printing.

"Our work with AUT has highlighted some of the processing shortfalls. The printing equipment needs to tolerate the irregularity of the feedstocks.

"Our focus will be on using materials sourced from primary industry waste.

We are particularly interested in sea shells that currently have no resale value and in some cases, incur disposal costs."

Marie Joo's expertise in biopolymers means she will concentrate on developing and testing suitable biomaterials for 3D printing. Based on their engineering and micro-tooling skills, scientists from Chemnitz University of Technology and AUT will modify 3D printers to suit bioresource use, which will be evaluated through complementary experiments. As Marie Joo says, "the partnership is built on existing synergies in 3D printing, with different but complementary expertise."

Stefan Hill will be using his \$150,000 to develop an additional method of authenticating bio-plastics. At present,

the only method of doing this is by using radioactive carbon (C-14) dating.

"Bio-based feedstocks provide a clean and sustainable source of polymers. However bio-plastics are, on average, more expensive to produce and therefore command higher premiums. Customers need to be confident they're getting what they pay for," says Stefan.

"Fossil-based materials do not contain C-14, whereas corn, for example, absorbs C-14 from the atmosphere. However, fossil-derived carbon dioxide can sometimes be used to enhance plant growth and this results in a bio-based plastic being reported as fossil-based instead. It's also easy to counterfeit a bio-based claim by doping fossil-based polymers with young carbon."

Stefan will be working with GNS and the Energy Research Centre of the Netherlands to investigate tritium-dating as an additional method of evaluating bio-based products. Tritium is a radioactive isotope of hydrogen and much more difficult to counterfeit. Having two methods of validation will add more certainty around the ultimate source of plastic and make it difficult for counterfeit products to enter the market.

"This is an opportunity to develop an enduring partnership with two other centres of excellence," says Stefan. "The Energy Research Centre of the Netherlands also helps set international standards for bio-products and this programme will elevate our existing relationship with them as an advisory partner on an EU programme to the next level as an active non-EU research partner."

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Urgent need for a global strategy on forest health

(Continued from page 1)

are using a wide variety of techniques combined with 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 bodies like the International Union of Forest Research Organisations (IUFRO) help facilitate collaboration, there is no single body or funding structure to support a

global strategy for dealing with pests in planted forests.

"It is important for New Zealand to maintain strong international networks to address the biosecurity challenge collectively and, through science partnerships including the New Zealand Biological Heritage National Science Challenge, help countries that may not have the resources or expertise to put biosecurity measures in place."

For further information

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Dr Warren Grigsby and his research team are making their bioadhesives commercially available.

Taking our bioadhesive technology to industry

Scion's environmentally-friendly bioadhesives and resins made from natural sources, are contributing to a reduction in the use of fossil resources and greenhouse gas emissions, reinforcing the New Zealand wood processing industry's licence to operate.

The winding road to commercialisation

It's been a long and sometimes sticky road to success for Scion's bioadhesives research team.

After seven years of learning to mix and match assorted ingredients from forestry and agricultural waste to produce a recipe for a healthy 'green' bio-based adhesive, the research team is ready to take their technology to the next step, industrial commercialisation.

The commercial availability of Scion's bioadhesives to the wood processing industry comes on the back of commercial trials held late last year, which involved the manufacture and product testing of the liquid resins at tonne-scale. Following this, commercial-scale trials were run at two industrial plywood mills, each using two different types of adhesive application.

Programme leader, Dr Warren Grigsby, says the trials were a great success. "We had to deal with a few teething problems along the way and learned new things in the process, but we're very happy with the outcomes.

"The mills had their own unique conditions and challenges to overcome. For example, each used different equipment with specific requirements, and the veneers they were using had different characteristics, but we were able to adapt our product to suit the different glue application methods of each mill and produce the desired result."

"Adhesives and resins made from natural sources have a lower environmental footprint and are considered more socially acceptable than their traditional formaldehyde-based counterparts."

Warren likens it to baking a cake where a range of products can be made by combining different ingredients. In this case, adhesives were adapted to suit interior grade plywood and laminated veneer lumber products. "Different formulations of adhesive have different properties, and the blend of ingredients depends on what wood finish is being

used, and the composite or wood panel being manufactured."

Getting the recipe right

New Zealand manufacturers of medium density fibreboard (MDF) have been looking at ways to reduce formaldehyde emissions of products for many years, in response to regulatory pressure from overseas markets. In late 2008, Scion initiated a research programme to create 'green' bioadhesives without using formaldehyde or petrochemicals.



Warren and his team had to start from scratch, extracting chemicals from forestry and agricultural residues such as Kraft liquor from pulp and paper mills, and arable crop processing waste. They then re-formulated the ingredients in new ways to create the building blocks for bioadhesives. After suffering a few flops along the way, the team eventually developed a recipe capable of holding together an MDF panel, and things started cooking from there.

At this stage, seeing a range of quality furniture made from wood panels using 'green' bioadhesives will be a well-deserved reward for seven years in the Scion master kitchen.

And, says Warren, the products' green credentials will provide manufacturers with a competitive advantage over wood panel processors using conventional petrochemical adhesives and resins.

"Adhesives and resins made from natural sources have a lower environmental footprint and are considered more socially acceptable than their traditional formaldehyde-based counterparts. We conducted an analysis of our bioadhesives in 2014, which showed the engineered wood products have a 22% lower environmental impact over their lifecycle than those using adhesives derived from petrochemicals."

Warren also spent several weeks at the Forest & Forest Products Research Institute in Japan last year, working on a collaborative project to assess emissions produced from wood panels made using bioadhesives, and their individual components.

The next step towards commercialisation of the products will be to fine tune formulations for the wider engineered wood products market.

"We measured the volatile organic compounds emitted during the hot press manufacturing of hardwood plywood panels made using our bioadhesives, and the subsequent emissions released over seven days. The results clearly showed that our bioadhesives have very low formaldehyde emissions, which were lower than wood alone, and that the use of our ingredients contributed to this.

"While we are still developing some of the fundamentals, such as the heat and flow interactions, we can confidently say our ingredients and formulations can be prepared to be truly recyclable,

compostable or durable in engineered wood products and packaging."

What does commercial success look like for bioadhesives?

In New Zealand, 20% of the plywood manufactured is interior grade and used for wall linings, doors and furniture. Warren would eventually like to see all interior grade plywood made using bioadhesives to support a healthier living environment for kiwis.

At this stage, seeing a range of quality furniture made from wood panels using 'green' bioadhesives will be a well-deserved reward for seven years in the Scion master kitchen. The panels produced during the commercial trials have already been released to several design companies to see what they come up with.

The next step towards commercialisation of the products will be to fine tune formulations for the wider engineered wood products and panels market, and for the packaging industry for use in liner and corrugated packaging boards.

Gold icing on top

The bioadhesives research programme received a Gold ranking by the Ministry of Business, Innovation and Employment, for performance and outcomes that



exceed expectations on an annual reporting basis.

This is a well-deserved icing on top the programme's success for Warren and the research team, after years of hard work to develop suitable products for scale-up, fostering industry relationships and international connections, and achieving the necessary steps towards commercialisation.

Sweet reward for a small, dedicated team of scientists.

For further information

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Adding value to research and commercialisation

Scion's new General Manager for Forest Science, Emeritus Professor Alison Stewart, is amazed at the breadth of research being undertaken at Scion.

Alison took up the position in February, having spent the past three years as Senior Vice President R&D and Chief Technical Officer at Marrone Bio Innovations in California.

"The extent of the research being done in manufacturing and bioproducts, in addition to forest science, makes my role even more challenging and exciting," says Alison. "The more I learn about the forest industry, the more I appreciate just how complex it is. There are layers and layers of stakeholders to consider - forest growers, wood processors and value-added manufacturers - each involved in different aspects of the industry. Many industry investors are from overseas too, which adds yet another level of complexity.

Alison has successfully developed and commercialised a number of bioprotection technologies for the agriculture, horticulture and nursery sectors in both New Zealand and the USA.

"I am slowly understanding now why forestry is quite a conservative industry. There are many moving parts and risk factors to consider, and predicting and forecasting are influenced by so many factors compared to short rotation crops, like vegetables."

Alison is from a background where innovation is easier to be adopted and for the benefits to be seen within a short timeframe. With forestry, she says, it could take up to 25 years to see the difference.



Emeritus Professor Alison Stewart

Alison has successfully developed and commercialised a number of bioprotection technologies for the agriculture, horticulture and nursery sectors in both New Zealand and the USA. She is currently on the advisory board of Better Border Biosecurity (B3), a government funded research consortium focused on the development and delivery of biosecurity systems, and is science advisor to the PGG Wrightson-led Primary Growth Project on biological seed additives.

Prior to working at Marrone Bio Innovations, Alison was founding director of the Bio-Protection Research Centre at Lincoln University where she also held various other roles including Professor of Plant Pathology. She was Deputy Chair

of Plant and Food Research (2011-13), a Director of the Waite Research Institute in Adelaide and, until recently, an advisory member of the California Institute of Food and Agricultural Research at the University of California (Davis).

"I came back to New Zealand because I wanted to apply my learnings from a commercial bio-tech company to add value to the research and commercialisation space in New Zealand. I see plenty of opportunities at Scion to do that."

"The science environment in New Zealand is challenging because we're so small and isolated. We therefore need to connect internationally to access new funding, or partner with overseas companies to deliver new technologies."

Alison believes in applying a global perspective to science and technology, and loves the challenge of "joining the dots" when it comes to creating new networks and partnerships in order to achieve the bigger picture.

"The science environment in New Zealand is challenging because we're so small and isolated. We therefore need to connect internationally to access new funding, or partner with overseas companies to deliver new technologies. This also adds a much broader perspective to our work.

"The next big step for me is to work closely with Dr Elspeth MacRae, Scion's General Manager of Manufacturing and Bioproducts, to further align of the work both our groups are doing to achieve more innovation at the interface between the different science disciplines and industry needs. That's where we'll see the greatest creativity happening."

For further information

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Capturing the beauty of pāua

The iridescent beauty of pāua shell may soon be captured in everyday household items. Materials scientists Drs Marion Sanglard and Marie Joo Le Guen are working with abalone farming company OceaNZ Blue to investigate possible uses for pāua (abalone) shells that are being discarded during processing. The project is partially funded through the Bioresource Processing Alliance.

Pāua shells are currently exported to Asian countries for processing into such things as decorative veneers, powders for cosmetics and homeopathy treatments. In 2014, over 50,000 tonnes of sea shells were exported to a value of \$385 million, representing a third of New Zealand's fisheries export revenue.

"Shells from gastropods and bi-valves such as abalone, mussel and oyster, contain plates of calcium carbonate that are cemented together by biopolymers and provide the shells with exceptional toughness," says Marion. "Calcium carbonate is commonly used as filler in the manufacturing of biocomposites, so we're investigating pāua as an exemplar resource for powders and polymer compounds for 3D printing. In addition to its natural toughness, pāua has a characteristic colour which will bring an intense visual impact to a product."

The pāua shells are ground into powders and made into composites via extrusion, injection moulding or 3D printing.

"We've proven the concept that paua shells can be used to make biocomposites for 3D printing, and are now evaluating their performance against generic calcium carbonate. If viable, this concept may be extended to include other sea shells, possibly generating an additional revenue stream for our fishing industry, rather than that value being realised off-shore."

A video featuring this novel technology was created for a video challenge competition for the inaugural ECO_BIO 2016 conference, held in Rotterdam in March. The video won the Popular Choice Award.



For further information

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View our award winning *Paua Power* video at: bit.ly/1RawXB5

VTT agreement opens global opportunities

A research collaboration agreement signed recently between Scion and the VTT Technical Research Centre of Finland will give New Zealand better access to global opportunities in the bioeconomy.

"This agreement sets a clear path for us to focus on co-invention and commercialisation of technologies that will contribute to increased use of climate friendly, lightweight, high performance materials made from forest biomass," says Scion CEO Warren Parker. "We have complementary science and technology capabilities and a good history of joint work. Under this agreement, we will also jointly target EU funding and approach global opportunities in the bioeconomy, particularly in Asia."

"Scion and VTT are collaborating on exciting research at the leading edge of global trends, such as novel carbon materials, nanocellulose applications, biorefineries and pulp, paper and packaging - areas of huge interest to high-value manufacturers."



Photo: Michael Bradley

VTT has a 73-year history as a centre of technological expertise and developer of new technologies. The first project under the agreement will adapt VTT technology for hardwood trees and apply it to New Zealand radiata pine to develop a new biobased film for the packaging industry.

VTT CEO, Dr Antti Vasara, says, "The bio and circular economy are global hot spot areas with huge technology potential where VTT and Scion can combine their competences and work together to open up new commercialisation opportunities."

For further information

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Building confidence in science

Scientists, students and teachers learning from each other. That's the aim of a two-year Vision Mātauranga programme Scion entered into with local Whakarewarewa School, in April 2015.

The programme is designed to forge a lasting connection between Scion and the school. Programme leader Kim McGrouther says the idea is to build the teachers' confidence in science and for students to be comfortable talking with scientists about science. "The hope is too, that a number of students will choose science as a career path."

To date, teachers from the school have visited Scion's nursery and laboratories, with reciprocal visits by scientists to talk to the students about water quality and biodegradable plastics. The students also played an active role in the ceremony to mark the release of white ngūtakaka back into the wild, visiting the nursery beforehand to learn about the plant and to practice pricking out seedlings.

"As part of the programme, I took two teachers and two students to the Science Communicators conference in Wellington, in November," says Kim. "The students presented a poster titled 'Talking to Nana and Koro', on kawakawa and its medicinal properties. They got second place. And they were the only children in the poster session, the rest were adults from universities and CRIs."

"I joined the students at Maketu estuary recently too, to help with their estuary studies, supervising four students for the day. That was a good learning experience for me!"

For further information

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New CEO for Terax 2013 Ltd goes global

The new CEO of Terax 2013 Ltd, Brian Vass, has set his sights on taking TERAX® technology to the world. TERAX® is an organic waste conversion technology jointly developed by Scion and Rotorua Lakes Council that offers an alternative to landfill, as well as generating income by recovering valuable chemicals and energy.

Coming from a background in developing multi-national businesses in Europe, Asia and New Zealand, and with extensive business experience in the fields of energy and technology, Brian sees the opportunities that lie ahead for this unique technology.

"I believe TERAX® waste conversion technology will improve our environment. Water is the number one issue in the world. We take it for granted, but many other countries don't have access to clean water.

"With the quality of the shareholders and the research behind it, TERAX® waste conversion technology can make a big difference to the world. The markets for it are huge especially in response to the Paris climate change agreement."

Brian has already been checking out opportunities in China, India and Japan.

"In China alone, there are some 200 large cities all needing to manage municipal

waste. The building of a commercial-scale plant in Rotorua will serve to demonstrate the technology to the rest of the world."



Brian Vass, Terax CEO.

Prior to joining Terax, Brian was Manager Subsidiaries at Meridian Energy and responsible for Meridian's portfolio of subsidiary companies worth over \$300m. He established Energy For Industry, which offers Waste to Energy plants, including landfill gas and biosolids, through Design-Build-Own-Operate contracts.

Brian says his real reason for being at Scion is because he is "committed to making a difference in climate change to provide a better future for our children." He believes TERAX® can make that difference.

For further information

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Virtual network of equipment for bioresource processing

Businesses and researchers throughout New Zealand can now access a range of test facilities and pilot plants to trial new bio-based products without having to invest in costly equipment.

A new online database called the 'Virtual Pilot Plant Network (VPPN)' provides business owners and product developers with information on equipment, plant facilities and technical expertise available around the country to help with all aspects of bioresource processing.

The VPPN has been put together by the Bioresource Processing Alliance, a Ministry of Business, Innovation and Employment funded research and development programme to help the primary sector turn its low value, high volume biological waste into high value products. The alliance combines the science expertise and technical facilities of four research institutes, Scion, AgResearch, Callaghan Innovation and Plant & Food Research, and their wider research and industry partner network.

The VPPN is free to access via the alliance's website, and is available for any New Zealand business or research organisation to advertise and showcase their pilot scale facilities at no cost.

For further information

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New Zealand Journal of Forestry Science



Scion's flagship scientific publication, the *New Zealand Journal of Forestry Science*, has an international scope that covers the breadth of forestry science. Volume 45 of the Journal is now complete with all 26 papers freely

available on-line. They can be viewed and downloaded from <http://nzjforestryscience.springeropen.com>

Working hard to protect New Zealand forests

Our *Forest Protection Annual Science Report 2015* is now available to download at www.scionresearch.com/fpscience-reports Or call reception on 07 343 5899 to have a printed copy sent to you.

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ISSN 2230 - 6137 (print) ISSN 2230 - 6145 (online)

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Scion Connections is published quarterly, and is also available online at www.scionresearch.com/scion-connections

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