



## Fuelling a greener economy

A report<sup>1</sup> released recently by the Royal Society of New Zealand calls on New Zealanders to take action against rising greenhouse gas emissions in an effort to curb global warming. New Zealand's emissions are well above average for developed countries, and steadily rising.

"About half of the greenhouse gas emissions come from burning coal, oil and gas for electricity, heat, transport and other everyday activities," says Dr Paul Bennett, Science Leader for Clean Technologies and co-author of the report. "This is an opportunity for us to reduce our dependence on fossil fuels and move to a low carbon economy."

New Zealand's transport system alone is 99% dependent on fossil fuels with a preference to send the majority of domestic freight by diesel fuelled trucks. Paul would like to see some real investment going into biofuels and bioenergy production, in a political landscape that encourages energy independence and addresses climate change.

"While the cost of some first generation biofuels, such as ethanol and biodiesel,

can be competitive with petroleum products, large scale production of advanced woody biofuels using existing processes is currently very costly. We need to drill down and see how the costs of both feedstocks and conversion technologies can be reduced, and how we can extract greater value from the co-products, such as biochemicals and bioplastics."

Current conversion technologies require oil prices to be \$100-\$130 a barrel in order to be viable, but the International Energy Association (IEA) estimates that future technology improvements will bring that price down to a more reasonable \$50-\$70 a barrel by 2030.

Scion has already started looking into the potential for large scale production and use of liquid biofuels using woody biomass and a range of other bio feedstocks. A two-year biofuels roadmap project is underway by a multi-disciplinary team of scientists to align investment with a policy framework and direction in resources,

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<sup>1</sup> The Royal Society of New Zealand. (2016). *Transition to a low-carbon economy - summary report*. Wellington, New Zealand.

# Where would we be without foresight?

In the last issue of *Scion Connections*, I outlined why the COP21 Paris Climate Agreement will profoundly reshape national economies and resource use. This includes New Zealand, where some sectors appear to still believe they can compete in a decarbonising world with 20th century technology. This is not a new revelation. Scion's scenario work in the early 2000s showed it was highly probable that economies would switch from fossil oils to plant and other low emission, renewable resources within a generation<sup>1</sup>. This set in place Scion's "Next Generation Biomaterials" research programmes and the development of bioenergy options for New Zealand.

Scion's strategic focus on this different, but highly plausible, future has received plenty of criticism over the years from parts of the forest industry and others who considered a dominant focus on incremental gains (or business as usual) was a more sensible pathway for economic growth. These voices were particularly strong when carbon, and later oil prices plummeted following the global financial crisis.

While Scion's scenario plans anticipated the rising cost and scarcity of oil would drive change more strongly than what we see now, they did highlight that the unacceptable risks posed by climate change would precipitate a transition to low carbon, renewable materials and sources of energy. As illustrated within this newsletter, the foundation work in the 2000s has led to internationally competitive facilities, equipment and expertise at Scion that businesses can now access to help them compete.

Important learnings can be drawn from this foresight:

- Science foresight must be encouraged to ensure economies and societies have options for their future in place. This should ideally occur at multiple levels - enterprise, sector and national. The "Environment and Conservation" and "Primary Sector" 20-30 year roadmaps on science direction are current examples.
- Science evidence and insights on future markets provide the basis for assessing the plausibility of scenarios. This evidence merits much higher credence by policy makers and business than the advocacy of sceptics and anti-science factions.
- Long-term competitive advantage for organisations increasingly comes from investing "ahead of the

curve" (i.e. discovery of unique intellectual property, and making "smart products"<sup>2</sup> using converging technologies in novel ways). Therefore business leaders need to apply a global context to ensure sufficient investment in mid- to long-term research (i.e. Horizon 2 and 3 in McKinsey's parlance) rather than solely focussing on problem solving and efficiency gains (Horizon 1).

- Traditional approaches to investment analysis are known to favour current practice over disruptive change<sup>3</sup>, therefore judging what is plausible in a future world must underpin choices for long-term research investment. Also, commercialisation approaches are often different for emerging growth sectors because their associated value chains disintermediate those already in place.
- A holistic approach is needed to spot patterns, avoid blind spots and identify cross-sectoral opportunities and risks. Diverse and fresh thinking is essential to achieve step change and shape markets.

Not surprisingly, Scion continues to place a high priority on foresight and gathering intelligence on emerging science, technologies and factors that can 'steer and grow' markets. In one sense, we are forced to because most plantation trees planted this winter will not be harvested until at least 2040. In another sense, these multi-decade timeframes require us to be flexible and agile by focussing on building knowledge and technology platforms from which many options can be launched.

The Biofuels Roadmap featured on the front page amply illustrates these features. The research, industry and policy experts are contemplating what New Zealand energy mixes could be in 2035 plus, and the role that our forests could play in this. These insights also inform how Scion's science workforce and facilities should evolve in order to support new materials science (such as for packaging and use in 3D printers), value chain design (distributed manufacturing), products for non-traditional markets (essential oils and food), and to facilitate international collaboration.

I welcome your thoughts on foresights and whether you think we have the balance right. I hope you can see from the research we report in this *Scion Connections* that it is worthwhile investing in.



Dr Warren Parker,  
Chief Executive



**Want to know more?** Contact Dr Warren Parker at [warren.parker@scionresearch.com](mailto:warren.parker@scionresearch.com)

<sup>1</sup> Scion. (2006). *Annual report*. [www.scionresearch.com/annualreport2006](http://www.scionresearch.com/annualreport2006).

<sup>2</sup> Porter, M.E., & Heppleman, J.E. (2014, November). How Smart, Connected Products Are Transforming Competition. *Harvard Business Review*.

<sup>3</sup> Christensen, C. (1997). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Boston, MA, USA: Harvard Business School Press.

# Mānuka as a tree crop

Kiwis have grown up with mānuka honey and tea tree oil but these humble household items are fast becoming a multi-million dollar forest industry for New Zealand.

Overall honey exports were \$242m in 2015<sup>1</sup>, having grown about 23% a year for the past decade, likely due to the specific demand for mānuka honey. Scion is currently working with the Bay of Plenty Regional Council to help deliver the Bay of Connections regional growth strategy for the wider Bay of Plenty, with a vision of creating a prosperous region supported by sustainable sectors. This complements the work being undertaken by the High Performance Mānuka Plantations Primary Growth Partnership (PGP) programme. The PGP programme is led by Mānuka Research Partnership Limited, partnering with the Ministry for Primary Industries.

**“Mānuka offers an opportunity to boost regional growth, especially for rural and Māori communities where land can be leased to apiarists. For example, we are working with East Coast iwi to identify land suitable to grow mānuka for honey and oil.”**

Forest scientist and interim coordinator for the Council's mānuka action plan, Bob

Shula, says the industry currently relies on native stands to supply the growing demand for mānuka. “The majority of these stands will mature naturally and transition to kānuka after about 25 years, creating uncertainty around the supply of pure raw material. This is likely to restrict investment and expansion.”

Bob says the first step is to generate a sustainable supply of mānuka as a plantation species or nurse crop to mainstream forestry species.

“Mānuka offers an opportunity to boost regional growth, especially for rural and Māori communities where land can be leased to apiarists. For example, we are working with East Coast iwi to identify land suitable to grow mānuka for honey and oil. We are also working with industry partners to develop high performing mānuka cultivars so growers can have more control over the quality of the final product.”

Soil scientist Dr Simeon Smaill says there are many unknowns around plantation mānuka. “We are seeing what we can apply from past research with other exotic and indigenous species in addition to

work we're doing with mānuka. The aim is to move from wild harvest to science based farming by combining improved genetics with best management practice.

**“This work is part of the wider programme to establish sustainable, resilient and productive plantations.”**

“Hedging for oil production could provide a secondary income stream, but it's not known if this can be combined with honey production. There is also the myrtle rust threat to address, so integrating resistance into breeding programmes is fundamental to the future of this industry. This work is part of the wider programme to establish sustainable, resilient and productive plantations.”

Deciding where those plantations are best grown is what Research Leader Melissa Evans is working on.

“We've developed a prototype analysis framework called Finding Opportunities for Resilient Mānuka (FORM), in partnership with East Coast iwi and other partners to assess the feasibility of growing mānuka for oil. The FORM framework assesses where plantations could be placed, where existing wild stands are growing, the costs of harvesting and distillation, and the total worth of the value chain.

“From this, we've created a series of maps specific to the East Coast that show the potential value of mānuka oil production. Our next step is to progress FORM as a stand-alone mānuka assessment tool incorporating both oil and honey production.”

Principal Technologist Graham West has been integrating mānuka economics into MyLand, a web-based model that provides a framework for long term land-use planning, with economic and environmental outputs over time.

“We collate the output from specialised farming or cropping models to give whole property cash flows while considering environmental and practical implementation constraints. The framework can create scenarios using pastoral farming, forestry and mānuka on the various geophysical blocks within a property. This makes it possible for landowners to compare options and make informed decisions about what to plant, and where, for the long term future.”

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#### For further information

Contact Bob Shula at  
[bob.shula@scionresearch.com](mailto:bob.shula@scionresearch.com)

<sup>1</sup> ANZ. (2015, Oct). *Agri Focus*.





Scion's WHITE room can test up to 25 corrugated boxes under accelerated conditions.

# Packaging – more than meets the eye

Most consumers are probably unaware of the science and innovation that goes into creating everyday packaging.

“New Zealand’s economy relies on exporting billions of dollars’ worth of products to distant markets, and packaging plays a huge role in maintaining the value of these exports,” says Packaging Research Leader Lou Sherman. “Two percent of all packaging fails. For large companies transporting millions of products to market, that can be costly.

“Scion is developing packaging that can perform better than that. Innovative packaging protects and adds value to a product by reducing the amount lost through damage. It also plays a fundamental role in marketing the product and reinforcing the company brand.”

From moisture barrier coatings to biobased films, and now intelligent packing that does its own inventory control, Scion’s packaging team is transforming the humble package into a high performance system.

## Lightweight and water resistant

“Package failure in the chilled goods supply chain is a big issue,” says Lou. “The length of time products are stored in these humid conditions puts moisture barrier performance high on most exporters’ wish list of requirements.”

“We’ve developed a high performance moisture barrier that is applied over the

top of ink. It also provides a high level of gloss that protects package branding so that the visual impact of a product is maintained right through to the end user.”

**From moisture barrier coatings to biobased films, and now intelligent packing that does its own inventory control, Scion’s packaging team is transforming the humble package into a high performance system.**

Key to the technology’s success, explains Lou, is that the coating is applied using the industry-standard flexo printing process, which means it can be applied in-house without the need for pre-coated material to be kept in stock.

“Multiple thin layers of coating are applied, which reduces both the total volume of coating used, and the costs involved. This technology helps to lightweight packaging. Less paper is used because the packaging is more moisture resistant, and therefore less waste is generated. And, the packaging is still fully recyclable. Our barrier coating technology could potentially save costs throughout each step of the chilled supply chain.”

## Testing the creep factor

One of the major causes of box failure is moisture accelerated creep, or deformation over time.

Scion’s WHITE room - an acronym for weight, humidity intervals, temperature and experiments - is a purpose-built coolroom designed to test exactly that.

The facility accurately cycles relative humidity between 50% and 90% while



maintaining a constant temperature. It's designed to measure how long a box will last under accelerated conditions, at what point it will collapse and how much load it can withstand.

"We can test up to 25 corrugated boxes at once using testers that apply constant loads," says Project Leader Dr Saad Hussain. "This facility has helped us to understand more about the humidity cycling parameters along the supply chain, so we can determine how a product will hold up a year from now by conducting tests over a two to three week period."

Saad says the WHITE room is quite possibly the only independent facility of this size in the world, which is why it's been running back to back experiments since it opened.

"There was a lot of interest shown in our packaging research capabilities at last year's TAPPI CorrExpo, which is the largest corrugated board expo in the United States. Since then, we have had leading American and Swedish packaging companies seek us out, and we have undertaken some collaborative projects with European companies.

**"Consumers expect to have a product, often from overseas, arrive in top condition. We also expect more from a box - pallets are double stacked, the materials are lighter and there is a higher demand for products."**

"We are now focusing on reinforcing the importance of moisture accelerated creep testing. The pulp and paper industry is a long-standing one that relies on a range of traditional tests, but these tests do not allow for the dynamic environmental conditions seen in real supply chains.

"Consumers expect to have a product, often from overseas, arrive in top condition. We also expect more from a box - pallets are double stacked, the materials are lighter and there is a higher demand for products. Moisture accelerated creep testing is very important."

Saad presented to industry at Appita last month and will do so again in October. He has also been invited to present at a technical meeting of Fiscotec at this year's TAPPI CorrExpo.

### **Clever ink for smart phones**

Inks that think mean manufacturers and consumers will soon be able to trace a product back to its source of origin, view a video that explains how the product was

processed, or connect to "the internet of things" and access valuable information about supply chains and consumer use.

Fibre scientist Dr Yi Chen says the possibilities are exciting. "This is intelligent packaging and it will be of huge benefit to New Zealand's export industry."

**"Intelligent packaging uses wireless technology. We are using special inks to print a NFC (near field communication) antenna circuit for a smart phone. In the future, this will be combined with sensing inks to create an active communication system."**

At present, once packaging is designed its ability to protect and communicate remains static. Intelligent packaging, on the other hand, will be constantly collecting and communicating information. This will have the ability to influence supply chain conditions and the marketing message being delivered to consumers.

The technology will eventually replace printed codes such as barcodes and

QR-codes, explains Yi, as these are easily damaged during distribution and need to be in the line of sight in order to be read.

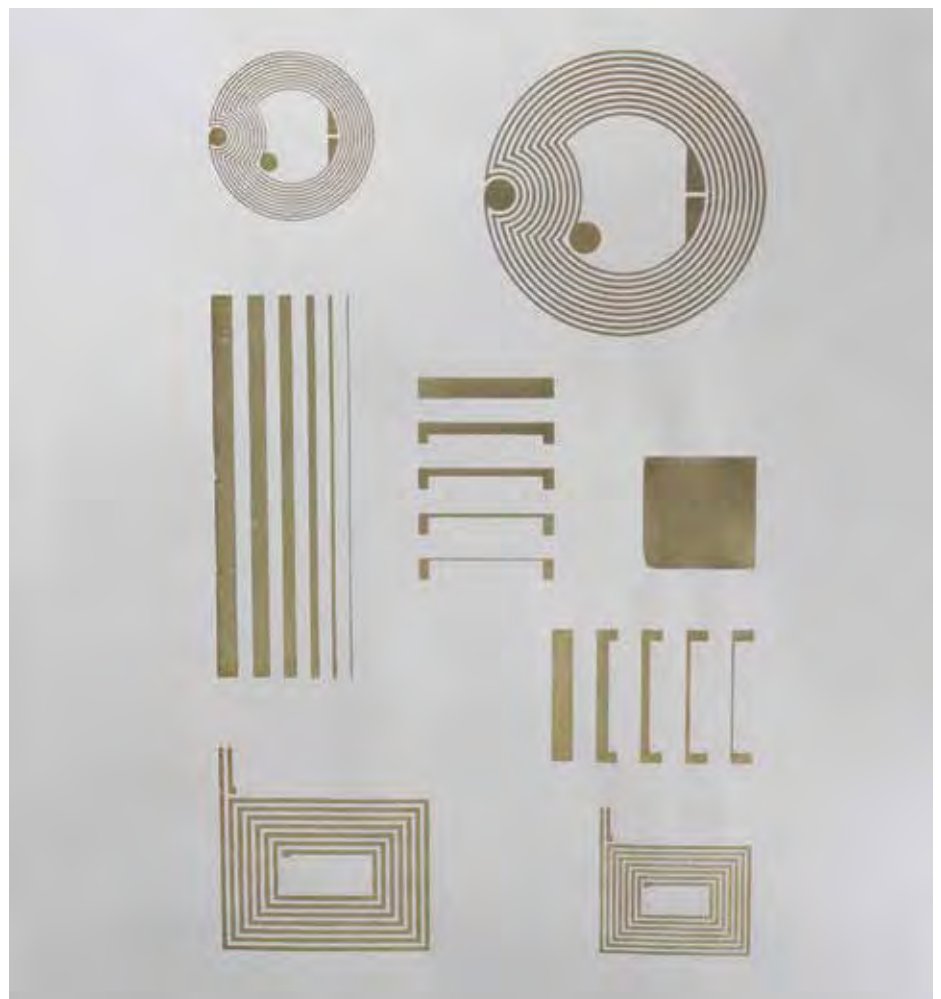
"Intelligent packaging uses wireless technology. We are using special inks to print a NFC (near field communication) antenna circuit for a smart phone. In the future, this will be combined with sensing inks to create an active communication system. Our Forest Industry Informatics team is currently developing a smart phone app that will read the information, convert it into digital code and then into usable information for manufacturers and consumers.

"Consumers will be able to use the app to scan the printed tag on the packaging to access information about the company and how the product is processed without even needing to pick up the carton. And the consumer can send information back to the manufacturer using the same app. It will also be an invaluable tool for logistics purposes, tracking products from the manufacturer right through the supply chain to the supermarket checkout."

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#### **For further information**

Contact Lou Sherman at [lou.sherman@scionresearch.com](mailto:lou.sherman@scionresearch.com)



*Special inks are used to print circuits for packaging that in future, will replace barcodes and QR codes.*

# Enhancing forest productivity with soil sciences

Our ability to understand and manage the links between soil properties and forest productivity is being expanded by the “Growing Confidence in Forestry’s Future” (GCFF) programme.

With the growing global demand for wood products and the realisation of a soon-to-be shortage of harvestable trees, Scion’s soil scientists are leading projects to improve the productivity of New Zealand’s planted forest estate through understanding and managing soil.

**“There are strong links between the physical, chemical and biological properties of soil, and forest performance. By promoting beneficial interactions it is possible to make trees grow faster, stay healthier and be more tolerant to stress.”**

“Forest health and productivity is dependent upon soil at all stages of development, from seedlings in the nursery to mature stands in the forest. However, assessing soil properties is a complex and often costly process, which has restricted research into forest soils in the past,” says soil microbiologist Dr Simeon Smaill. “The GCFF programme is giving us an opportunity to explore how soil and soil processes respond to management practices in partnership with forestry stakeholders.

“There are strong links between the physical, chemical and biological properties of soil, and forest performance. By

promoting beneficial interactions it is possible to make trees grow faster, stay healthier and be more tolerant to stress, using techniques that can be applied in new and existing plantations. As part of this work we are developing new methodologies in soil microbial and genetic analysis.



“We want to explore why different tree genotypes that are planted in the same site can recruit different, and sometimes better, soil microbes. Good site preparation can enhance the beneficial activity of microbes too, so by understanding the science behind these phenomena, we can tailor management activities to get most

out of soil and the resident microbial community.”

Simeon says this work may be expanded in the future to examine triggers that regulate the activity of harmful pathogenic soil microbes, providing new options to help control tree diseases.”

“Ensuring the long-term sustainability of soil resources is also a key component of the GCFF programme,” says soil scientist Loretta Garrett. “This is important to the maintenance of both forest productivity and industry licence to operate over multiple rotations.

“Our goal is to establish long term management systems for forest soils that are economical to establish, and that enhance the environmental benefits they provide.”

To achieve this goal, the GCFF programme is driving efforts to bring new levels of precision to forest soil monitoring and management. This includes the use of new tools such as a sensing device capable of measuring soil properties by projecting electro-magnetic pulses underground to a depth of 1.6 metres. Combining this with traditional soil sampling methods will make it possible for Scion’s scientists to characterise forest soils in far greater detail than ever before.

Embedded in all of Scion’s soil research is the need to understand how New Zealand’s forest soils will respond to climate change. Simeon and Loretta have led recent pan-CRI efforts to identify how soil processes will respond to the various impacts of climate change, and the likely implications for our primary sector industries.

## For further information

Contact Dr Simeon Smaill at [simeon.smaill@scionresearch.com](mailto:simeon.smaill@scionresearch.com)  
<https://gcff.nz>

## Fuelling a greener economy

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technology, distribution and use. The project has already attracted interest from a cluster of highly influential industry players from government, industry, interest groups and other researchers.

Project coordinator, Dr Ferran de Miguel Mercader, says the first step will be to develop a quantitative model that can test a range of biofuel scenarios, and then define these using variable feedstock, technology and cost inputs.

Ferran says, “The results will be refined in consultation with stakeholders and then an actual roadmap developed that will chart the future direction for biofuels in New Zealand. The map will identify key

industrial areas, transport routes and location of various feedstocks to provide clarity around investment into the sector.”

Scion has a number of other projects feeding into this work that will contribute to the larger biofuels picture for the country. New technologies are being developed or adapted for use in New Zealand, along with evaluating a range of feedstocks, including trees.

As Paul says, woody biomass is the most likely feedstock for biofuels, and planting new forests to supply the market will also serve to remove large volumes of carbon dioxide from the atmosphere and offset our greenhouse gas emissions.

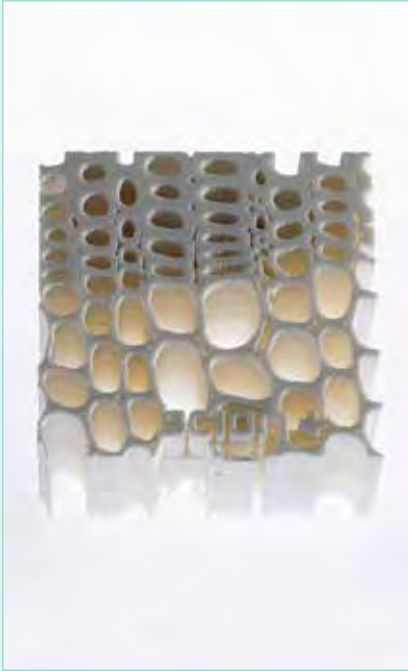
“For woody biomass to become a major feedstock for biofuels, we need a far greater supply than what’s currently

available from forestry slash, industry residue and construction debris. We have enough to get us started, but the costs of retrieving slash are limiting. We may have to start planting purpose-specific high density bioenergy forests that would look quite different to the forests we have now, or look at alternative feedstocks.

“But the climate is definitely changing and we do need to start acting immediately. It’s vital that we de-carbonise the energy sector and that we start planting trees now.”

## For further information

Contact Dr Paul Bennett at [paul.bennett@scionresearch.com](mailto:paul.bennett@scionresearch.com)  
<http://bit.ly/1m9tjzH>



## Scion's novel tool for sawmill students

New recruits to the sawmill industry will get a better picture of timber grains and how to saw them with a new training tool created at Scion.

Using Lloyd Donaldson and Alan Dickson's microscopic images of radiata pine, these digital images have been converted to 3D computer model drawings and then to file for 3D printing. The result – 3 D printed wood samples showing the internal structure of timber.

Each sample is about the size of a coaster. Alan, who is working on the project, says it takes at least four hours to produce one sample depending on the complexity of the image and subsequent computer model drawing.

The aim is to give recruits a visual tool to assist them in learning about timber grains and processing.

Four samples have been sent to industry for training production line staff at New Zealand sawmill sites.

Feedback from training provider, Training Support New Zealand, has been positive. A spokesperson says they are delighted with the samples.

The training course is designed to be practical and hands-on as many of the recruits have low levels of formal education.

### For further information

Contact Alan Dickson at [alan.dickson@scionresearch.com](mailto:alan.dickson@scionresearch.com)

## Managing risk in forestry

Combating the effects and rising costs of climate change was one of the issues discussed at this year's Growing Confidence in Forestry's Future (GCFE) conference, held in Auckland in May.

The GCFE programme aims to sustainably double the productivity of existing and future forests. "The programme has enabled us to assess long term productivity trials that were established in the 1980s for wood yield and quality, and tree value," says Science Leader Dr Peter Clinton. "These trials are providing valuable information on the interaction between site, genetics and forest management on wood quality and the ultimate value of the crop.

"Crop stocking is generally too low to take full advantage of site potential, but while a higher stocking rate will increase yield and wood quality, there is a greater proportion of lower quality core wood to consider. This research has shown though, that productivity gains can be achieved without compromising wood quality."



The trials are also providing information about the effects of nutrients, water, soil and climate on productivity. By comparing predicted with actual site productivity, our scientists have been able to identify areas around the country that are not performing at their best.

"These data are being incorporated into our forest nutrient balance model, NuBaIM," says Peter. "The use of UAVs equipped with powerful sensors has also boosted our ability to identify superior trees in the forest. We then identify the parent trees using DNA sampling and reproduce them for similar sites within the forest."

### For further information

Contact Dr Peter Clinton at [peter.clinton@scionresearch.com](mailto:peter.clinton@scionresearch.com)  
<https://gcfe.nz>



## Wood plastic takes global market by force

Scion and licensing partner Sonae Indústria are one of twelve finalists in this year's KiwiNet Research Commercialisation Awards. Together they have commercialised an innovative wood fibre reinforced plastic branded as Woodforce.

"Plastics made with wood fibre are stronger and stiffer than plastics alone but until recently, have not been commercially feasible," says Business Development Manager Jeremy Warnes. "Scion's patented process forms wood fibre into "dice" that can be made in existing MDF plants and easily added to a range of plastics.

"With most composite plastic manufacturers being outside New Zealand, we looked for an MDF manufacturer with a global reach who could be a key party in a complex and unfamiliar value chain. European MDF manufacturer Sonae Indústria was granted an exclusive licence for the technology in North America and Europe. Sonae owns and has developed the Woodforce brand."

End products using Woodforce are more light weight, thermally stable and sustainable than existing plastic materials and are being trialled and approved by major automotive manufacturers.

"Ultimately, the product will end up in plastic parts such as in cars, appliances, furniture and a wide range of consumer goods," says Jeremy. "The commercial potential is very large. Figures are hard to define for a range of reasons, however, we believe that the potential could ultimately be in the 100's of millions in business generated on a global scale."

KiwiNet award winners will be announced on 30 June.

### For further information

Contact Jeremy Warnes at [jeremy.warnes@scionresearch.com](mailto:jeremy.warnes@scionresearch.com)



# How do we value forest ecosystem services?

New Zealand's green image is an integral part of our identity, adding value to both our exports and tourism. Our forests contribute to this image by providing a range of ecosystem services such as habitat, water quality, carbon sequestration, erosion prevention and recreation, the value of which is not well established.

So how can a value be placed on something that, in many cases, can only be perceived? This is something Scion's team of resource economists specialise in. Scion's annual Forest Ecosystems Services forum also provides a platform for our scientists, government, research organisations and forest industry representatives to share knowledge on current perspectives at a national and international level. This year's forum focused on issues and pathways to implementation.

"People do value the intangible benefits provided by forests," says Dr Richard Yao. "Our survey of 1000 households shows that the average New Zealand household would willingly pay about \$200 a year to conserve key native species in planted forests. Likewise we can represent values on the tangible environmental benefits. For example, about \$250 million a year could be saved through avoided erosion if another 2.9 million hectares of forests were to be planted.

## Upcoming event

**Packaging workshop.** 9.00am - 4.00pm, Thursday 7 July.

In conjunction with NZ Institute of Food Science Conference. Further details are available on the event section of our website.

"Many ecosystem benefits can be gained from sustainable forestry. As an example, one major forestry company has established about 17 hectares of freshwater crayfish ponds within the forests. As a result, they sell about 300 kg of 'keewai' every year in addition to conserving a threatened species, and demonstrating that their management practices are reducing sediment runoff and producing clean water. This is illustrated by the success of their freshwater crayfish venture.

"What was highlighted at this year's forum is that we need to provide more

robust information and education around the importance of ecosystem services. We also need to develop mechanisms for their implementation such as a universal economic model for valuing ecosystem services to increase their visibility in policy and investment decision making."

**For further information**  
Contact Dr Richard Yao at  
[richard.yao@scionresearch.com](mailto:richard.yao@scionresearch.com)

See also: [www.youtube.com/watch?v=JKmsOW7sMUM](https://www.youtube.com/watch?v=JKmsOW7sMUM)



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**SCION**   
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49 Sala Street,  
Private Bag 3020,  
Rotorua 3046, New Zealand  
Telephone: +64 7 343 5899  
Facsimile: +64 7 348 0952  
[www.scionresearch.com](http://www.scionresearch.com)