Scion connections

SCION forests · products · innovation

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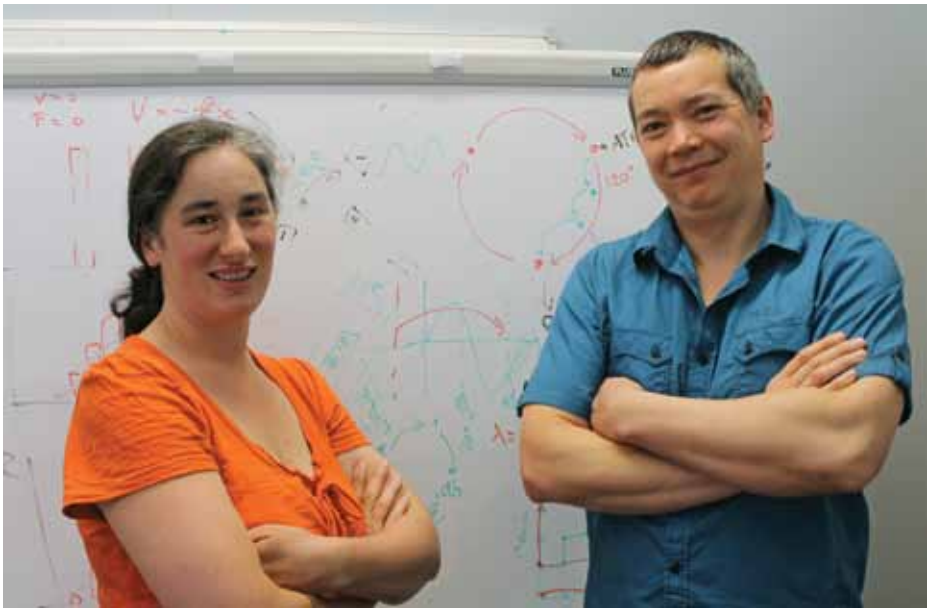

Drs Katharine Challis and Michael Jack explain their theory for molecular-scale energy conversion.

Molecular motors drive energy technologies

Scion may, at first glance, seem an unlikely place to house a team of theoretical physicists.

The team, comprising Dr Katharine Challis, Phuong Nguyen and Dr Michael Jack are working on molecular motor research and their findings have been published recently by the American Physical Society. Their research is pushing the boundaries of our knowledge in both physics and biology disciplines. It may have major implications for the future of bioenergy.

Molecular motors are specialised proteins that biological systems (including cells) use to convert energy from one form to another. These nanoscale (i.e. one-billionth of a metre) devices operate in an environment dominated by heat fluctuations. At this tiny scale, molecular motors perform their tasks with up to 97 per cent energy efficiency – far surpassing the most efficient industrial processes.

The big question, as yet unanswered, is how molecular motors operate to achieve this unprecedented efficiency. The answer lies in a branch of physics called Brownian motion – a phenomenon described by Einstein over a 100 years ago. Brownian motion describes the random motion of a particle in a liquid or a gas.

The answer lies in a branch of physics called Brownian motion – a phenomenon described by Einstein over a 100 years ago.

Einstein's mathematical equations have been adapted to partially explain how molecular motors work – but to date, there is no explanation for their phenomenal efficiency. Katharine and Michael have a compelling mathematical theory of energy conversion in molecular motors. They hope to test their theory against single-molecule experiments at some of the world's leading laboratories. While their work to date is almost entirely theoretical, there are real world applications behind this research. Fundamental understanding of biological energy conversion could provide clues for developing new highly-efficient industrial energy technologies. This is the sort of knowledge that will support Scion's goal of providing leadership in New Zealand's developing bioenergy, biorefining, and industrial biotechnology industries.

A quick primer on molecular motors is available at *www.scionresearch.com/molecular-machines*

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Contents

The forest industry must confront Dutch disease to reach $12 billion export target

The Government has set an ambitious goal to lift New Zealand's export earnings from the current 30 per cent to 40 per cent of Gross Domestic Product (GDP) by 2025. For primary sector industries this means at least doubling export earnings to more than $60 billion.

The forest industry has a plan to do its part - grow exports from the 2011 baseline of $4.7 billion to $12 billion by 2022. The essential ingredients to achieve this are at hand – an increasing log harvest and much of the required processing and transport infrastructure, and innovation capacity. However, the industry also needs help particularly to improve the profitability and scale of the wood processing sector, since reaching the $12 billion goal is heavily centred on raising the proportion of logs processed onshore from the current 45 per cent to at least 70 per cent.

This is a particular challenge because other countries, notably China, want our logs and other natural resources, either un- or minimally processed. When such demand is strong, as at present, this contributes to a phenomenon *The Economist*, in 1977, coined 'Dutch disease' or, as abstracted from Wikipedia, "..where an increased exploitation of natural resources is associated with a decline in the manufacturing sector because increased revenues from natural resources [logs] contributes to a strengthening of the nation's currency and reduces the export competitiveness of domestic [wood] manufacturing."

The Dutch experienced this with the discovery of a large gas field in the late 1950s; Australia experienced it through the recent mining boom; New Zealand is seeing this with an apparent insatiable global demand for our milk and logs. Given the increasing world population, mostly in developing countries, and associated growing shortages of land and water (and thus food, fibre and energy) this seems highly likely to continue.

Economies are not this simple, and the present effects of large scale and sustained quantitative easing in the US and Japan on the New Zealand currency illustrates this. But it does highlight the need for New Zealand to be proactive and deliberate if Dutch disease is not to be repeated here for our wood manufacturing sector.

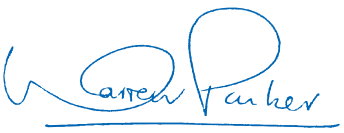
The forest industry recognises it has to do its part by improving process efficiency, such as by applying lean thinking; increasing product innovation, such as by increasing returns from sawmill residues; and, collectively, branding and marketing better. However these steps are not sufficient in themselves; help is needed to quickly update building standards, for example, for engineered wood products; increase confidence to invest in new plant and equipment, such as through accelerated depreciation on these items across the manufacturing sector; ensure a level playing field in free trade agreements; and, encourage the use of wood in construction (as in Japan and British Columbia with their Woodfirst procurement policies). Domestic development of the forest industry is vital too, because export growth must occur through increases in value as well as volume. Simply increasing the volume of commodities is unlikely to enable sustainable land management or improved water quality. The Parliamentary Commissioner for the Environment's (PCE) latest report, *Water quality in New Zealand: Land use and nutrient pollution*, highlights this reality.

Farmers face two primary constraints: reduced availability of land that is suitable for conversion to more intensive production such as milk and crops; and a limit to the capacity of these ecosystems to absorb associated higher fertiliser inputs. The PCE has highlighted Canterbury and Southland as regions facing an increased future water quality challenge – the Commissioner could also have added the central North Island.

You do not have to think too deeply about the Commissioner's report to conclude that forests have a complementary role with lowland intensification to help mitigate nutrient run-off and leakage. In these situations we need to be thinking not only of traditional forests but also of special purpose, high biomass growth - three to four times that of pasture - forests harvested at 10-15 years of age. "Industrial forests" with these characteristics are common in South America and, as best I can judge, there is no biophysical reason why we cannot do likewise.

The achievement of the 40 per cent GDP target requires a more encompassing and diverse view of the economy than that presently offered by many commentators. As some crudely put it – a future prosperous and resilient New Zealand is going to need to be much more than a big dairy farm and a large conservation estate! Our challenge in the forest industry is to tell our story better about our scale; environment friendly growth; low carbon technology; and hazard and fire resilient construction materials. The articles in this newsletter illustrate these qualities, as does our new 'Prosperity from trees' vision video (see the last page for access details).

As always I welcome any comments and feedback you might have.



Warren Parker, Chief Executive

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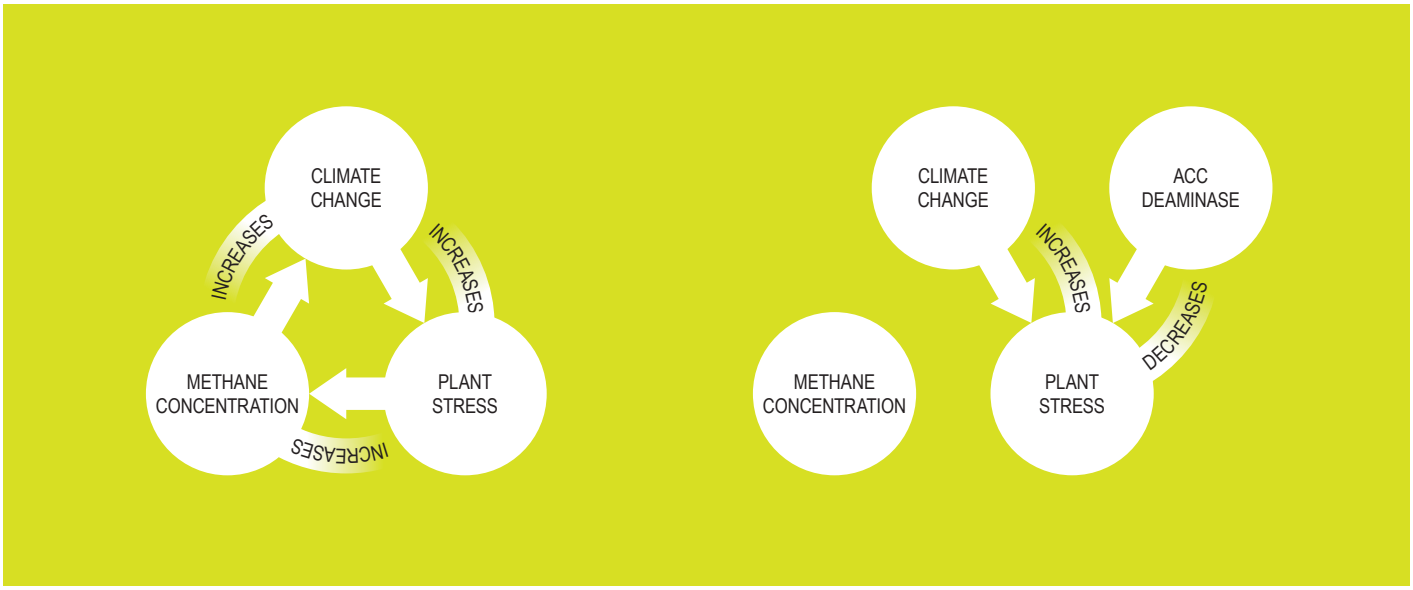

Plant growth promoting bacteria in the soil produce ACC Deaminase, which reduces a plant's production of excess ethylene when under stress.

Soil bacteria may promote tree growth and mitigate climate change

Research into how a group of growth promoting bacteria help plants cope with environmental stress may have major implications for scientists worldwide trying to piece together the full picture of global warming.

The less obvious impacts of a changing climate have Scion's microbial ecologist Dr Simeon Smaill digging below the surface of the soil to investigate what effect these changes may have on a plant's capacity to produce food and fibre in the future. Simeon's research into the pivotal relationship between plants, soil bacteria and global warming has recently been published in the prestigious international journal, *Trends in Plant Science*.

"It's a vicious circle," says Simeon. "Extreme weather as a result of the changing climate places plants under stress. In response to this stress, plants produce massive quantities of ethylene, initiating short term survival tactics such as leaf loss and reduced growth. In many cases, this reaction causes more damage to the plant than the stress itself.

"It's a vicious circle," says Simeon. "Extreme weather as a result of the changing climate places plants under stress."

"However, ethylene also blocks a process in the soil where bacteria called methanotrophs break down methane. The result is that the soil cannot capture methane, leaving more in the atmosphere. With methane being a major cause of global warming, the extreme weather – plant stress – methane production cycle is accelerated."

Methane is a potent greenhouse gas and although present in small concentrations is responsible for a large portion of global warming, second only to carbon dioxide (CO_2). Any alterations to the methane concentration in the atmosphere will therefore have a considerable effect on global warming and weather conditions.

"There are many sources of methane – livestock, fossil fuel production and wetland emissions," says Simeon. "But there are only two sinks – atmospheric oxidation and oxidation by these soil methanotrophs, which are found predominantly in forest ecosystems."

Preserving the methanotrophs' ability to capture methane when plants are subject to stress may prove a vital key to regulating the methane-global warming balance, and this is the core of Simeon's research. The activity of a second group of "plant growth promoting bacteria" – so called due to their abilities to improve plant productivity - may provide the answer. These bacteria have the ability to slow down a plant's production of ethylene by producing an enzyme referred to as ACC-D[1].

"Plants normally produce ethylene at low concentrations as part of their physiological processes. What we are interested in is being able to stop a plant producing excess ethylene when it's under stress.

"The enzyme ACC-D reduces a plant's production of ethylene and allows it to respond to stress more effectively. This has been proven to increase plants' tolerance to stress. It may also limit the amount of ethylene released into the soil, allowing methanotrophs to continue breaking down methane.

"For instance, we have already noticed there are some radiata pine strains that have greater levels of the ACC-D enzyme in the surrounding soil, suggesting there is some sort of signalling going on between those particular plants and the bacteria. This probably helps makes these strains more tolerant to certain stressful conditions like drought, for example.

Preserving the methanotrophs' ability to capture methane when plants are subject to stress may prove a vital key to regulating the methane-global warming balance.

"We want to capture this information. While there is detailed knowledge around some aspects of plant physiology, we don't yet fully understand the complex relationship between plants, microbes, and soil systems.

"It's possible we may be able to harness these ACC-D producing bacteria not only to help plants cope better under stress, but also to address a significant piece of the global warming jigsaw, helping future proof both planted forests and wider plant ecosystems against a changing climate."

[1] 1-aminocyclopropane-1-carboxylate (ACC) deaminase

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Understory intercropping has the potential to change how forests are planted in the future.

Ginseng adds a layer of possibilities for forestry

Neat rows of netting cloches lined up beneath well pruned radiata pine trees are in sharp contrast to the usual vision of a commercial planted forest block.

The small, unassuming ginseng plants beneath the cloches belie their potential to be a game changer in the profitability of forestry in New Zealand's central North Island, and possibly other temperate zones across the country.

Research conducted recently by Scion for Māori forestry organisation Maraeroa C Incorporation, into where ginseng could grow within the central North Island and the additional value gained from growing it as an understory intercrop, shows promising results.

"We have appreciated the opportunity to work on this project with Maraeroa C and their motivated ginseng team, and we are all very excited about the results," says Loretta Garrett, Project Leader and Soil Scientist at Scion. "Growing ginseng commercially as an understory intercrop could potentially double the profitability from the land compared to forestry alone over one rotation, which means huge benefits for the community and the economy."

Ginseng has been used as a Chinese medicinal herb for centuries. The Chinese are the biggest users of ginseng and grow 90 per cent of the global crop. They also import large quantities from Korea and North America to supplement their own supply.

Several attempts have been made to grow the two better known Asian and American species here in New Zealand but until now, little research has been done into the critical environmental requirements for ginseng in this country or its value.

"Growing ginseng commercially as an understory intercrop could potentially double the profitability from the land compared to forestry alone over one rotation, which means huge benefits for the community and the economy."

Maraeroa C has been trialling ginseng at its King Country estate since 2006 with the first crop due to be harvested in March next year. Along with particular soil, land slope and climate requirements, ginseng requires a high level of shade making planted forests an ideal environment in which to grow the herb.

Chief Executive of Maraeroa C, Glen Katu, approached Scion to help determine what the optimal conditions for growing ginseng were and other areas in the central North Island with similar conditions, as well as its economic value as an export.

"There are nearly 450,000 hectares of pine forests in central North Island, with Māori some of the biggest owners of forestry land in the area," says Glen. "We wanted to scope the potential for them to grow ginseng as an understory intercrop, and the social impacts it may provide for these areas, the viability of overseas markets and what contribution ginseng may make to the country's economy as a whole.

"Understory intercropping has the potential to change how forests are planted in the future to allow optimal spacing and a good environment for growing crops like ginseng."

Ginseng is a slow growing perennial herb, taking 14 years to reach maturity in China but only seven years to reach maturity in New Zealand due to having twice the growing window than the snowy climates of North China and Korea. Naturally grown wild ginseng is considered the most valuable product, but years of severe over-harvesting means it now accounts for less than one per cent of the global production.

The majority of ginseng is cultivated - planted underneath artificial canopies or trees at high densities and subject to intensive chemical and mechanical treatment. The application of fertilisers means a shortened rotation and results in well fattened roots which are predominantly used in tonics or capsules or used as additives to soaps, shampoos, lozenges and such.

A wild simulated ginseng plant.

However, it's the 'wild simulated' ginseng - planted in an environment close to its natural range, grown organically and harvested by hand - that commands prices second to those received for wild grown. This is the method that Glen and his team have been trialling, specifically targeting the largest and most demanding of markets.

Ginseng is a slow growing perennial herb, taking 14 years to reach maturity in China but only seven years to reach maturity in New Zealand due to having twice the growing window than the snowy climates of North China and Korea.

As Glen explains, the American species of ginseng promotes *yin* energy and is therefore cooling. This is often used by younger people or those in warmer climes. The Asian species is the *yang* energy, warming the body and being much favoured by older Chinese users – the largest segment of ginseng users worldwide.

"We saw a gap in the Chinese market for wild simulated ginseng – grown naturally with no fertilisers or pesticides used. Aesthetic attributes are just as important. It takes longer to grow and the roots are much smaller but are more highly valued. They are kept whole to be given as gifts, or sold to Chinese pharmacies for use in traditional medicines."

In New Zealand, there is a growing window of about 15 years for ginseng as an understory intercrop to radiata pine; planted after final thinning from about 12 years when the canopy provides sufficient shade. Results of Scion's research indicate its success as an understory intercrop will depend on specific soil, light level and climate, with a degree of winter chilling and positioned on gentle to undulating slopes for good air and water drainage, and site access.

Once the land is cleared, prepared and fenced to protect against grazing pests, ginseng seed is planted and then covered in netting to protect against birds. Seven or so years later, the roots can be harvested – in this instance, manually which Glen expects will take two or three minutes per root. Premium prices are achieved only if the root is undamaged and the myriad filaments and hairs attached to the root remain fully intact.

After drying, roots are packaged so their beauty and shape can be clearly seen. Any damage received to the root during harvesting relegates the product to second grade and is priced accordingly.

Although the risks are high, wild simulated ginseng may have a huge bearing on the profitability of forestry, providing earlier returns and considerable long term employment opportunities. Conservative estimates indicate ginseng could potentially double profitability compared to forestry alone, returning an additional 154 - 188 per cent value per hectare of planted forest. With an expected fresh yield of 675 kilos per hectare (225 kilos dried) returning $2,000 per kilo for dried ginseng, the economics are clear.

Results of our research also indicate over half of the 450,000 hectares of planted forests in the central North Island has suitable environmental and geophysical conditions to grow wild simulated ginseng. The benefit for New Zealand's economy could be huge.

Maraeroa C assisted six Māori forestry trusts install ginseng field trials on their estates last year. But as Glen says, they are assessing how it fares and no doubt, how Maraeroa C's first harvest is received in the Chinese market.

The scoping ginseng research project was supported with funding from the Ministry of Primary Industries.

About ginseng

Two of the 11 species of ginseng are grown commercially. The Asian species (*Panex ginseng*) is thought to promote *yang* – hot, positive, male energy which warms the body, favouring people living in cold places. American ginseng (*Panex quinquefolius*) promotes *yin*, or cold, negative, female energy which cools and calms the body, making it more suitable for warmer months.

Ginseng is used as an all-round tonic to restore and enhance normal well-being. It is thought to boost energy, lower blood sugar and cholesterol, reduce stress, promote relaxation and treat diabetes. Ginseng's main constituent, ginsenoside, is also believed to have anti-inflammatory properties.

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

Understory crops add flavour to forestry

Understory cropping may extend further than ginseng. Scion is working with Tarawera Land Company to improve the economic sustainability of their forested lands. The project centres on 21,000 hectares of radiata pine in the Kawerau region and is also exploring concepts for secondary crops within the wider Bay of Plenty.

"At present, most plantation forests in New Zealand are under-utilised," says Project Leader Marie Heaphy. "We are looking at plant species that have the potential to grow as understory crops in radiata pine plantations, and provide earlier financial returns and diversified yields as well as employment opportunities for the region."

Marie and Resource Economist Dr Richard Yao have analysed crops for site suitability, potential market and economic return. Of those found suitable for the Tarawera area, three were analysed in more depth – goldenseal and two native species, kawakawa and patē, all of which show promise.

Kawakawa is an indigenous species that is used for culinary, medicinal and cosmetic purposes. The market for kawakawa products is growing locally and overseas, and international demand for quality goldenseal root, used for herbal preparations, continues to exceed supply.

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Scion's software engineering team can now refocus on developing software to support internal research projects.

Software tools to access science

The sale of Scion's commercial software brand, ATLAS Technology, to local company Integral Limited will allow our software engineering team to refocus on what they do best – finding innovative ways to deliver science to industry through software.

As Chief Executive Dr Warren Parker explains, the time was right for a new owner to lead the vision and direction of the ATLAS brand.

"We looked for the right company to expand and grow functionality and usability of the ATLAS products while being committed to the New Zealand forest industry. The sale will increase our capacity, through Integral, to provide high quality innovative decision support tools to increase forest productivity, health and profit."

The software engineering arm of Scion goes back nearly 30 years. It stemmed from an industry need for comprehensive forest management and analysis tools at a time when no such technology existed. A group of dedicated people at Scion (or what was then, the Forest Research Institute) pooled their expertise to build a suite of products to meet that need.

One such tool was GeoMaster which was released in 1992 and still remains a leading industry standard forest estate management and land information system. Today, GeoMaster is utilised by about 60 per cent of the country's commercial forest companies. Since its release, the team has continued to produce and maintain a suite of forest management, harvesting, quality assurance, inventory information and yield analysis software.

ATLAS Technology was formally established by Scion in 2002 to accelerate further development and to make the expanding suite of forest management software commercially available to industry. GeoMaster, along with the majority of ATLAS products will now be taken care of by Integral, however Scion will retain ownership of its cable harvest planning software and FFR Forecaster, which was produced in partnership with Future Forests Research.

The software engineering arm of Scion goes back nearly 30 years. It stemmed from an industry need for comprehensive forest management and analysis tools at a time when no such technology existed.

The sale of ATLAS means Scion's software engineering division, part of the Forest Industry Informatics team, is now able to re-focus on its roots - building solutions to support internal research projects, as well as the technology transfer of science through software to industry.

"Commercial software requires considerable support and ongoing reinvestment to maintain its operational acuity," says Research Leader Bryan Graham. "Integral is the right company to move GeoMaster and the other systems forward and to take good care of our clients. They are committed to New Zealand forestry.

"Our team can now focus on developing software to support internal research projects, for example, decision-making software, stand metrics and performance platforms, and mobile platforms for devices such as smartphones and tablets.

"We are looking at innovative ways to put the latest science at the fingertips of our users.

"The sale of ATLAS frees the team up to be more creative and positions us as a neutral entity to work with commercial companies to get the software out to a wider audience."

Integral Ltd assumes ownership of ATLAS Technology from 1 January 2014.

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Integral Limited

Integral is a long serving provider of software and solutions to the forest industry. Established in 1991 specifically to service the timber and forest industries, Integral provides services for major forestry companies including Carter Holt Harvey, PF Olsen, Timberlands Limited and many other large and small organisations.

Integral Ltd is New Zealand owned and is located in the Te Tipu Innovation Park adjacent to Scion.

Ash from waste wood is rich in micronutrients.

Going the full circle

Pulp and paper mills are large producers of organic and inorganic waste, much of which is either burnt for energy, vermicomposted or landfilled. Our Clean Technologies Team has been working with four pulp and paper companies and project management firm Sinclair Knight Merz to explore alternative solutions for the solid waste that is currently landfilled.

Waste wood at these sites is burned and the ash generated is rich in the micronutrients calcium, magnesium and potassium. The team is exploring additional uses for the ash such as in fertiliser and aggregate.

Ash applied directly to certain forest species from a particular age has been shown to increase tree volume. The ash is also being used as a liming agent, receiving interest from local fertiliser and compost companies as a potential resource.

"The project has increased awareness at the mills of the impact their energy systems have on the environment," says Research Leader Dr Kim McGrouther. "The mills are now looking more closely at how they operate their boilers, and some of the mills are already employing the new initiatives. This awareness is also extending to other ash-generating industries.

"There is the potential to reduce solid waste going to landfill annually by approximately 25,000 tonnes. Not only will this considerably reduce the mills' landfill costs, it also has a huge benefit for our environment by putting the micronutrients back into the ecosystem."

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Gaining greater value from our biological resources

An alliance between four national research providers has been established to aid the recovery of high value co-products from New Zealand's primary industries.

The Bioresource Processing Alliance (BPA) taps into some of the best technical facilities, research and processing knowledge available in the country through the alliance between Scion, AgResearch, Plant and Food Research and Callaghan Innovation. Each partner is already actively engaged in research to derive greater value from low value biological streams.

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

The BPA will enable industry partners to gain access to raw materials from across the whole primary sector along with the opportunity to produce high value co-products from low value biological raw materials. It will also provide the opportunity to create industry clusters across whole value chains, and generate employment with potential spin-off for secondary industries, such as engineering for plant design and construction.

The Bioresource Processing Alliance is a government-subsidised initiative, with $2.5 million per annum available over the next five years for technical and industry development.

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Fish box made from ZealaFoam™.

Award recognises excellence in innovation

Biopolymer Network Ltd (BPN) won the 2013 Innovation Excellence in Research category at this year's New Zealand Innovators Awards, for its revolutionary bioplastic foam, ZealaFoam™. The award celebrates research that has excellent potential and impact.

ZealaFoam™ is an eco-friendly bioplastic alternative to expanded polystyrene (EPS) foams that can be manufactured on existing EPS production lines with little modification. BPN Chief Executive Sarah Heine says the award gives ZealaFoam™ an industry stamp of approval that will likely accelerate its uptake as a substitute for EPS.

"It's produced using a truly green process, using renewable and compostable material, and adapting to existing manufacturing plants with minimal investment. It's a great opportunity for BPN and New Zealand to have international impact in a market where there are few, if any, truly environmentally friendly alternatives. ZealaFoam™ protects the market share of New Zealand exporters using EPS, and also enables access to new markets where sustainability is the key and the use of EPS is frowned upon."

The award provides BPN global recognition as a leader in biopolymer foam technologies. Biopolymer Network Ltd is jointly owned by Scion, AgResearch and Plant and Food Research. The biofoams project received Ministry of Business, Innovation and Employment investment.

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Scion's vision for prosperity

At Scion, we create prosperity from trees. From bark to fibre, we use trees in clever ways to build a better bio-based economy.

Our scientists are constantly devising new products and technologies that minimise our impact on the environment. We are helping New Zealand's forest and land owners make the best economic and environmental use of their land to create a better future for all New Zealanders.

Our new vision video will show you how our science helps us achieve this.

Search for Scion on *www.YouTube.com* or click on the link from our Home page, *www.scionresearch.com*

Christmas closing hours

Scion will be closed from 5pm, Friday 20 December and will reopen on Monday, 6 January 2014.

The staff at Scion would like extend all of our clients and colleagues best wishes for the festive season and we look forward to working with you again in the new year.

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Follow us on LinkedIn and keep up to date with Scion's latest news, developments and technologies. We also promote upcoming job vacancies and new videos about our science expertise and capabilities.

Search for Scion on *www.linkedin.com* or simply click on the link from our Home page, *www.scionresearch.com*

Upcoming events

ForestWood 2014.
Te Papa, Wellington. 19 March 2014

A pan-industry conference that provides an opportunity for organisations and individuals with a keen interest in forestry to engage with decision makers and professional specialists from the forestry industry.

Jointly hosted by Forest Owners Association (FOA), Wood Processors Association (WPA), Pine Manufacturers Association (PMA), Forest Industry Contractors Association (FICA) and supported by Woodco, NZ Farm Forestry Association (NZFFA) and Frame & Truss Manufacturers Association (FTMA). Co-sponsored by Scion.

For programme information, and to register, visit *www.forestwood.org.nz*

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