Scion connections

SCION forests · products · innovation

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Doubling forest productivity sustainably

A multi-disciplinary team of scientists at Scion and other research organisations is embarking on a six year research programme aimed at raising the profitability of current and future commercial forestry.

The programme is a joint initiative between Scion, the forest growing industry and the Ministry of Business, Innovation and Employment that will combine world leading technology with an in-depth knowledge of plant growth sciences to improve the value of forestry through sustainable intensification.

The Ministry has allocated $3.375 million a year funding to the project with a further $1.6 million a year commitment from forest growers.

"This is one of the most significant initiatives undertaken by the sector," says Russell Dale, recently appointed Research and Development Manager for the New Zealand Forest Owners' Association. "It is focused on improving the value of existing forests and doubling the productivity of future forests. The forestry industry has a target of increasing the value of New Zealand's forest exports to $12 billion by 2022. This requires a major investment in new and upgraded processing facilities that will only be possible if processors can be assured of a stable wood supply.

"Other land users strive to improve the value of products produced from each hectare of land through intensification. The forest industry must do likewise in order to remain competitive. Furthermore, this intensification must be within environmental limits to ensure our access to international wood markets is protected and that forests continue to make positive contributions through delivery of a variety of ecosystem services such as the improvement of water quality."

Doubling productivity will require precision forestry, integrating the latest advances in sensor technology, tree physiology, genetics and forest ecology, and vitally, working closely with industry to solve problems. The research programme targets where improvements can be made throughout the forest growing cycle for both current and future forests that will boost productivity under intensified management regimes, while maintaining wood quality and the quality of the environment.

"The forests that will provide timber and wood fibre for the next 15 years are already growing," says Scion Science Leader Dr Peter Clinton. "We are therefore targeting mid-rotation treatments to increase tree growth and considering options to realise

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'Growing confidence in forestry's future' is aimed at raising the profitability of commercial forestry.

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Forest grower levy changes oversight and coordination of research

The introduction of a forest grower levy from 1 January 2014 has ushered in a new organisational arrangement for forest growing research and development. A Forest Grower Research and Development (R&D) Committee will oversee the further development of the industry's Science and Innovation Plan, priority setting, and the monitoring of growers' investment and members' fees into research programmes and projects. The Forest Grower Levy Trust Board is serviced through a secretariat of the New Zealand Forest Owners' Association (FOA), and the R&D Committee provides oversight and advice on priorities to FOA and the Levy Trust Board. Further detail about these new structures and their scope and purpose is available from Forest Voice *(www.forestvoice.org.nz)*.

The new structures will enable better coordination of all forest growing research, for example forest biosecurity research is now under the purview of the R&D Committee. Like all structural change these new entities will take time to fully bed in, but with levy collection under way, the transition is progressing well.

A consequence of the change is that Future Forests Research Limited (FFR) will cease operations from 31 March 2014. FFR was established in 2008 and over the past six years has done a fantastic job in profiling forest industry R&D, technology transfer, and engagement with members about their research needs. Scion is delighted that FFR CEO Russell Dale has been appointed manager of R&D for the FOA. Russell works closely with the Forest Grower R&D Committee. His knowledge of the industry and the science system is extremely valuable in ensuring a smooth transition to the new arrangements.

Scion's new Ministry of Business, Innovation and Employment (MBIE) programmes – *Growing Confidence in Forestry* and *Addressing Phytophthora Challenges* (outlined in our September 2013 edition of *Scion Connections*), are tightly integrated with industry needs. We are looking forward to seeing lifts in forest productivity, measurement and surveillance, and tree health as outcomes of this research. Alternative species research – Douglas-fir, eucalypts, cypresses and redwoods – is continuing under the management of the R&D Committee, with levy and Scion core funding investment, and with links to the Dryland Forest Initiative *(www.nzdfi.org.nz)*. The Primary Growth Partnership Steepland Harvesting Programme, which continues to be funded by member contributions rather the levy, will remain within a separate company but will be overseen by the manager of the Forest Grower R&D Committee.

The Radiata Pine Breeding Company, which continues as a stand-alone company *(www.rpbc.co.nz)*, is initiating an exciting new five year research programme in genomic selection. This programme includes the sequencing of the radiata genome and applying genomic techniques to substantially improve the rate of genetic improvement in our forests. Areas of interest include increased tree growth and uniformity, and disease resistance. This research, with RPBC's existing programme and industry linkages, and core funded work at Scion on genomics and genetic modification, will reassert New Zealand radiata pine breeding being at the forefront of international tree breeding efforts.

The value of investing in research and innovation is indisputable. If the New Zealand forest industry is to remain globally competitive and a land use of choice, it is essential that our R&D is sustained at world's best practice. At Scion, we are well prepared to meet this challenge and look forward to working with all of the new appointees to the Forest Levy Trust Board and Forest Grower R&D Committee.

Warren Parker, Chief Executive

Want to know more? Contact Dr Warren Parker at *warren.parker@scionresearch.com*

Doubling forest productivity sustainably

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more value from the logs harvested, while learning more about these trees in order to create better forests in the future."

"We are building on our current understanding of tree growth and wood formation. We need to gain a better understanding of how fundamental processes within individual trees (genotypes) and the overall ecosystem are influenced when we add, for example, water, fertiliser or a bio-stimulant. This level of knowledge is required to optimise the match between tree genetics, management practices and environmental conditions, and to guard against unintended consequences."

The programme involves many layers of research, central to which will be the development of a forest 'phenotyping platform' capable of providing information about the 'in the forest' performance of different genetic material under a range of environmental conditions. These data will enable superior trees, such as those with improved disease resistance and more uniform wood quality, to be identified for breeding programmes.

"Doubling productivity is an ambitious goal and one that requires significant new research to achieve," says Peter. "However, it's important to understand what the effects of intensification may be on the subsequent planting of sites. Responsible stewardship of soil and water quality, biodiversity and recreation opportunities is critical to the forest industry's licence to operate. Our access to international wood markets depends on this."

Collaborators include Landcare Research, University of Auckland, Waiariki Institute of Technology, University of Canterbury, Oregon State University, Université Laval and CSIRO.

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Dr Warren Grigsby is developing adhesives from natural sources.

Environmental impact of bioadhesives encouraging

Scion scientists Drs James McDevitt and Warren Grigsby have calculated that the benefits of bio-based adhesives extend beyond addressing health concerns. They have an environmental footprint 22 per cent lower than their traditional counterparts and this is increasingly sought by customers of forest products.

For several years New Zealand manufacturers of medium density fibreboard (MDF) have been working to reduce formaldehyde emissions of products in response to regulatory pressure from overseas markets. Health concerns in the United States and Europe around these emissions have resulted in higher demand for "green" panel products.

Responding to this challenge and to ensure markets remain open for New Zealand wood composite products, Warren is developing adhesives from natural sources such as tree bark.

The scientists used a Life Cycle Analysis (LCA) to calculate the environmental impact of producing either conventional adhesives or adhesives from biological sources. The bioadhesives had a 22% lower environmental impact over their entire lifecycle than conventional adhesives derived from petrochemicals. The main reason for lower environmental footprint was because they were created largely from New Zealand forest products. In contrast, conventional adhesives are created from petrochemicals that are transported from distant Middle East oilfields.

On the downside, a larger land area is needed to create the ingredients for bioadhesives. Even here Warren sees an environmental advantage since that land is producing sustainably grown forests. The bioadhesive manufacturing process uses parts of the tree that would otherwise go to waste.

Although not accounted for in the LCA study, Warren adds that new end of life options means that bioadhesives in MDF fibreboard can be recycled or someday can be composted back into orchards or farms. The composting option will need to wait for industrial composting plants to become more common. Neither disposal option exists for current formaldehyde containing board.

These findings can create marketing opportunities and possibly price premiums for new MDF products incorporating bioadhesives.

For the New Zealand wood processing industry, this sort of LCA quantifies the environmental impact of new products and can help bolster the industry's licence to operate when it can be demonstrated that new products are environmentally superior to their traditional counterparts.

The research is funded by MBIE.

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Dr Paloma Moncalean (left) and Cathy Hargreaves in the laboratory.

Are hybrid pines the super trees of the future?

Hybrid pines are promising to play an increasingly important role in commercial forestry, particularly for the cold, dry southern regions of New Zealand.

Field trials of *Pinus radiata x P.attenuata* hybrids established by Scion and forest tree seed company Proseed in the late 1990s, show the now mid-rotation hybrids to be tolerant of cold and dry conditions, and to have good resistance to snow.

The hybrids were first produced as possible alternatives to radiata pine for southern conditions. Parent trees were selected for growth and form, and seedlots trialled at various South Island sites. Sixteen years later at mid-rotation, the hybrids are demonstrating the cold and snow resistance of *P. attenuata* combined with the faster growth of *P. radiata*. The hybrids are performing well at altitudes of around 300 – 800 metres (above sea level) where neither individual parent species grow well. Their open crown form also helps them withstand the strong winds common to these regions. Core samples are currently being tested at Scion to compare wood density of the hybrids to that of the individual parent species.

"Based on these results we have been promoting hybrids to South Island forest growers and making seed commercially available for the past five years," says Shaf van Ballekom, Proseed Chief Executive. "These hybrids show superior performance with good resistance to cold and drought compared with the individual species. Companies have already begun planting them particularly in snow prone areas.

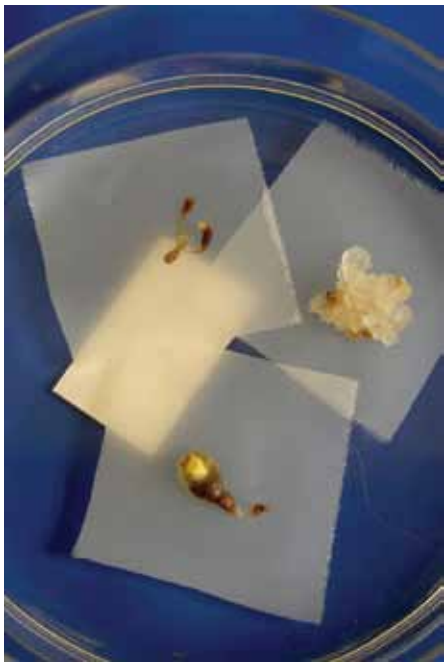
"The hybrids are ideal for the south and may provide a solution for land owners in high country areas where the declining viability of extensive livestock farming has spurred an interest in afforestation."

"In 1994, there were an estimated two million hectares of land in the South Island high country with potential for forestry."

The growing demand on land for agriculture and urban development often means commercial forests are increasingly being planted on marginal, dry and more mountainous sites. The increasing occurrences of extreme weather events as a result of the warming global climate also create an environment where hybrids such as these may prove a valuable commercial resource for the future.

Field trials conducted with Proseed and Edendale nursery, show *P. attenuata x P. radiata var cedrosensis* thrives in hot, dry summers and snow-laden winters.

According to Dr Heidi Dungey, Science Leader for Forest Genetics at Scion, many hybrid *Pinus* species have been created in the past to obtain trees better adapted to environmental conditions than the pure species alone. "Our aim is to eventually test these hybrids on other sites around New Zealand for their potential as a commercial forestry species for cold, dry and exposed areas.



Embryogenic tissue of P. attenuata x P. radiata var cedrosensis *on agar.*

"In 1994, there were an estimated two million hectares of land in the South Island high country with potential for forestry. The climate in these regions is colder and drier than the rest of the country, and this hybrid offers a real alternative to existing pine species for these conditions, particularly in areas where resource consent may be an issue."

Behind the scenes

Scion tissue culture specialists, in conjunction with scientists from Neiker-Tecnalia in Spain, are developing propagation strategies of the hybrid *Pinus attenuata x P. radiata var cedrosensis*.

Field trials conducted with Proseed and Edendale nursery, show *P. attenuata x*

P. radiata var cedrosensis thrives in the hot, dry summers and snow-laden winters of areas such as the South Island's McKenzie Basin. The Neiker-Tecnalia team has been studying the physiological aspects of the hybrid's resistance to drought in glasshouse-based trials using seedlots supplied by Proseed.

Research leader for the Neiker-Technalia team, biotechnologist Dr Paloma Moncalean, is currently on a 12 week sabbatical to Scion, funded by the OECD[1], to help advance the propagation protocols and integrate the process with current nursery practice.

"Progress with our experimental work has been excellent; so far it looks like our hybrid initiations are going to be as good as our best results working with protocols previously developed at Scion."

"Using our expertise in somatic embryogenesis from previous work with *Pinus* species, we have generated hundreds of new cell lines of the hybrid," says Cathy Hargreaves, Scion's micropropagation specialist and research leader in Forest Genetics. "These cell lines – populations of cells with the same genetic material - consist of embryogenic tissue that contains thousands of small embryos. This has the potential to reduce the cost of propagation and, more importantly, facilitate the storage of embryogenic tissue while field testing of the identical material takes place.

"Field testing allows us to see the potential of the new cell lines. If they perform well over the next five to ten years – by showing good growth and high tolerance to drought and snow - we can go back to the embryogenic tissue stored in liquid nitrogen and produce thousands of identical plants for afforestation.

"Progress with our experimental work has been excellent; so far it looks like our hybrid initiations are going to be as good as our best results working with protocols previously developed at Scion. This is tremendously encouraging. It opens up huge opportunities for continued collaboration between our organisations as we optimise proliferation, cryopreservation and maturation protocols for the hybrid.

"We hope to be able to one day screen new genotypes in-vitro for their field drought resistance. We want to obtain a super tree able to grow through the future climate change scenarios."

[1] *Organisation for Economic Cooperation and Development*

For further information:
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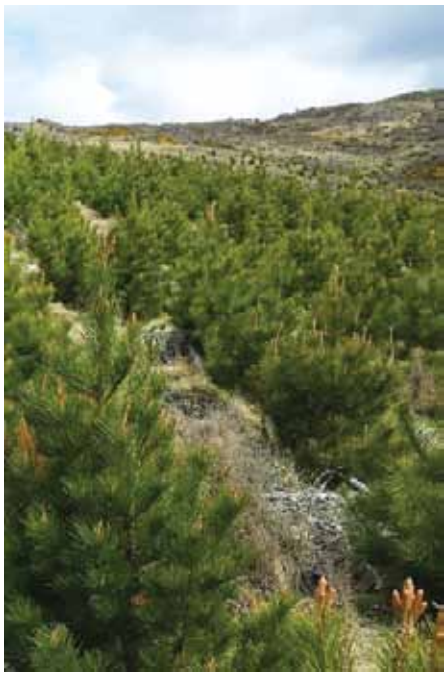

Hybrid pines are being trialled at various South Island sites.

Proseed New Zealand

Canterbury-based Proseed New Zealand Ltd is seed supplier to the New Zealand forest industry. For further information contact Shaf van Ballekom at *shaf@proseed.co.nz* or visit *www.proseed.co.nz*.

Shaf van Ballekom examining hybrids.

The tree-to-tree machine can move using trees as supports.

Tree swinging robot may revolutionise steepland forestry

A remote controlled tree 'swinging' robot modelled on stick insects and spider monkeys may revolutionise the way steepland forests are managed and harvested.

The two-armed forest locomotion robot, nicknamed 'Stick Insect' because of its deliberate movements, can be manoeuvred from tree to tree without touching the ground, using a joystick control. The device has been developed by Scion in partnership with the University of Canterbury, Future Forests Research and the Ministry for Primary Industries under a Primary Growth Partnership Programme to improve worker safety in steep, rugged terrain.

"The challenge is to develop a lightweight remote controlled machine that can move over steep, difficult and sensitive terrain without causing damage to the ground, and yet tackle productive tasks such as felling trees, cost-effectively."

"I've been working on the concept of a tree-to-tree machine for over 10 years, and this funding has enabled the project to progress," says developer Dr Richard Parker, Senior Scientist at Scion. "The challenge is to develop a lightweight remote controlled machine that can move over steep, difficult and sensitive terrain without causing damage to the ground, and yet tackle productive tasks such as felling trees, cost-effectively.

Richard based his design for the Stick Insect on the ways animals and insects propel themselves through the forests.

"The Scion tree-to-tree machine, or 'Stick Insect', is a mobility platform. We have been trialling the device in the mechatronics and robotics laboratory at the University of Canterbury to better understand its operating capabilities and are now working to incorporate gadgets to perform tasks, such as sensors for measuring tree diameter, and custom-built saws for felling."

Richard based his design for the Stick Insect on the ways animals and insects propel themselves through the forests.

"Animals have evolved over millennia to move effortlessly between trees. The most impressive are spider monkeys and gibbons which can swing from tree to tree at high speed. I simply borrowed that concept and worked with a team of scientists and engineers to develop the prototype of a mobility platform based on that."

Richard built the initial working models himself from balsa wood with syringes for hydraulic rams. Scion recognised the potential of the idea and in 2009 developed a strategic theme around the tree-to-tree concept. One of the outcomes was the first radio controlled tree-to-tree device built with colleague Matt Watson (ScanTec Ltd). The FFR and MPI funding provided the opportunity to do some serious engineering with the University of Canterbury.

"We envisage that we can eventually develop a whole family of tree-to-tree robots which can perform productive tasks in the forest."

With guidance from Professor XiaoQi Chen and Dr Stefanie Gutschmidt, Scion sponsored four students from the University of Canterbury Department of Mechanical Engineering to design and construct a quarter-scale working prototype as their final year research and development project. As Richard says, students Tom Gilbert, George Wareing, Scott Paulin and Sean Bayley showed great engineering flair by creating, designing, assembling and testing the components and control systems into a final working device. The prototype Stick Insect has a 2.2 metre reach and weighs about 50 kilograms.

"The device is lightweight but robust, and can move using the trees as supports. Its full weight is supported by grippers on the end of each arm so it does not contact the ground at all," says Richard.

As part of the FFR programme, Richard is currently working with the university's PhD students Chris Meaclem and Bart Milne, and Paul Milliken (Cutover Systems Ltd) who are developing instrumentation and software to better control the device. Richard is hoping to secure further funding to incorporate other functions.

"We envisage that we can eventually develop a whole family of tree-to-tree robots which can perform productive tasks in the forest. Large robots to fell trees, smaller robots to prune and measure trees - perhaps even refuelling robots. They will still need humans to oversee their operation and maintenance, but they will be at a safe distance away from hazardous operations."

The Scion tree-to-tree machine has been developed in collaboration with the University of Canterbury, with funding support from Future Forests Research and the Ministry for Primary Industries through the Primary Growth Partnership for Research.

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Technical Assistant Andrew Pugh with Prionoplus reticularis *larva (huhu grub).*

Raising healthy pests will gain insight into their behaviour

Our entomologists are working with Plant and Food Research to rear common wood and bark eating pests in the laboratory in order to gain a better understanding of their seasonal breeding cycles. This will help us define the start-finish times of a non-fumigation period for log exports, when the risk of pest infestation is low. Having a collection of healthy pests available will also support the development and testing of new phytosanitary treatments as alternatives to methyl bromide.

"We have successfully reared both the golden-haired bark beetle *(Hylurgus ligniperda)* and the burnt pine longhorn beetle *(Arhopalus ferus)* in the laboratory through a complete generation, and been able to induce egg-laying," says entomologist Dr Cecilia Romo.

"The insects were fed on an artificial diet and kept at a constant 25°C temperature in incubators, which increased their rate of development by about 50 per cent compared to those in the wild. The burnt pine longhorn beetles grew from newly hatched larva to adult in as few as 73 days, whereas in the wild, this takes a year."

A large number of black pine bark beetles, *Hylastes ater*, have also been collected in a collaborative trapping exercise between the two organisations for fumigation testing and to further investigate artificial rearing technologies and diet.

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Value of biodiversity in planted forests

Scion economist Dr Richard Yao says New Zealanders would be willing to pay to see wildlife in pine forests. Planted forests, which include pines and eucalyptus, provide a habitat to over a hundred threatened species in New Zealand. Many of these areas occur next to native forests and help extend the habitat range of some species.

Richard interviewed more than 200 New Zealanders asking which species they valued the most in forests. Bird species such as the North Island brown kiwi and native bush falcon were considered most valuable. The kokopu (a native fish), the green gecko and the endangered flowering kakabeak, less so.

Interviewees were also asked what they would be willing to pay to see or hear these species more often. On average, people were willing to pay $20 and $30 per year to hear kiwi more often in forests or have a greater chance of seeing bush falcons. On average, respondents were willing to pay less to see kokopu, green geckos or kakabeak more often. This is likely a reflection of the extreme rarity of these species and public unfamiliarity with them.

For policy makers and forest owners, these economic valuation studies provide the tools to value production forests for more than just their timber value. Knowing the value of carbon stocks, biodiversity, unique habitats, clean water and recreation helps build a more complete picture of a forest's value.

This research is published in the journal, *Ecological Economics*.

Ngutukaka, or Kakabeak.

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Strengthening our global network

A delegation from VTT Technical Research Centre in Finland visited Scion recently, meeting with scientists from our manufacturing and bioproducts teams. The visit was an opportunity to explore a more formal connection between Scion and VTT by way of scientist exchange, sabbaticals and shared post-doctoral research.

VTT is regarded as a globally leading multi-technological research organisation, with about 3000 employees. A collaborative agreement currently exists between our two organisations for the research and technology adaptation of novel carbon materials from lignin, biorefineries, nanocellulose applications, pulp, paper and packaging and other global trends.

"Finland's forestry industry is similar to New Zealand's," says Dr Elspeth MacRae, General Manager for Manufacturing and Bioproducts. "The sector accounts for about a fifth of the country's export revenue and is a major employer, but it also needs to keep abreast of rising production costs, and the decreasing demand for paper."

"We are working with VTT to develop and implement innovative and sustainable technologies and processes that are aimed at better utilising our forestry resources. We are also aiming to aid cross national commercial uptake of novel technologies in both New Zealand and Finland."

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Forest Protection annual science report for 2013

Scion has released the Forest Protection annual science report for 2013, highlighting our achievements in forest health and biosecurity research for the year.

One of the more outstanding achievements has been the allocation of $10 million funding from the Ministry of Business, Innovation and Employment over the next six years to lead collaborative research into *Phytophthora* species. This project offers an opportunity for New Zealand to become global leaders in *Phytophthora* research.

Also, our entomologists have been furthering their work in determining a fumigation-free period for New Zealand's log exports through the establishment of a national pest trapping network. The

network is already having benefits with data being used by the Ministry for Primary Industries to evaluate post-fumigation exposure periods.

A new Fire Weather System has been developed by our fire researchers to provide fire managers access to fire weather information, forecast data and danger conditions across the country. Our pest management scientists have also developed two new aerial spray application methods for pest eradication in sensitive locations, such as urban environments. These are the first tools in a toolkit of spraying techniques the team hopes to develop over the next few years.

These are just some of our achievements. To read more, you can obtain a copy of the report by contacting Reception or visit our website: *www.scionresearch.com/general/publications*

Super computer to crunch nanocellulose data

The New Zealand e-Science Infrastructure (NeSI) has granted Scion scientist Dr Stefan Hill access to its supercomputers to model cellulose nanocrystal x-ray diffraction patterns. The national computing research infrastructure's high performance computers allow researchers to tackle complex research questions. This resource is open to all universities and CRIs in New Zealand.

Equations that describe how x-rays interact with atoms work well for simple materials, but they do not work well when applied to nanocellulose. Nanocellulose is the crystalline form of cellulose – a major component of wood. One approach is to model as many combinations of nanocellulose structures as possible and to match these computer models with the Synchrotron X-ray experimental data. This task is beyond the ability of any computer at Scion.

"I would need to run this problem on my desktop computer all day and night for two or three years just to get an answer," says Stefan. "The high performance computing facility at NeSI will give us an answer in just days." This new information will provide insights into cellulose synthesis in woody plants and impact on the use of woody plants for biofuels.

Upcoming events

"Ahead of the Pack" workshop. Scion, Rotorua, 28 March

Inaugural packaging workshop tailored for professionals in marketing, manufacturing, quality and procurement who rely on packaging to make their business a success. The workshop will present global trends in packaging and bioplastics, and information on the latest supply chain and end-user demands. Scientists from Scion, other Crown Research Institutes and universities will be presenting.

NZ Farm Forestry Conference. Blenheim, 11 – 15 April

This year's theme is 'Diverse Landscapes'. Hosted by Marlborough Tree Growers Association and sponsored by Scion. Visit *www.nzffa.org.nz/conference* for further information.

Entomological Society of New Zealand annual conference. Rydges Lakeland Resort, Queenstown, 11 – 24 April

This year marks the 63rd anniversary of the conference. Scion is a conference sponsor. Further information will be issued closer to the date. Visit *ento.org.nz/conferences/conference-2014* for details.

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