Scion connections

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Segregation of raw material is seen as an immediate challenge.

Is wood quality still relevant?

Planting forests is a long term commitment. Choosing the right trees and management regime requires good site knowledge and a long term perspective about the future value of wood. It also requires a better understanding of what constitutes quality from a consumer's perspective.

Only a small premium is paid for higher quality logs in the current market, with maximum returns achieved through increasing log volume. The recent market domination by China has also blurred traditional quality criteria accepted by local wood processors, making this an opportune time to reassess just how important wood quality is for our major markets now and into the future.

Scion recently held two workshops in Rotorua and Christchurch for forest growers, tree breeders, wood processors, researchers and log buyers to discuss issues such as wood quality, market trends and future prospects.

"There was a lot of comment about the China market and how this is influencing wood quality," says Dr John Moore, Research Leader for Tree Growth and Quality. "China has traditionally had few quality demands, which offers an easy way to deal with wood variability, but it is likely that the uses of radiata pine in China will change as middle class society aspires to follow western trends.

"Some structural markets prefer Chilean radiata pine over New Zealand pine because of the smaller knot size, and we must not lose sight of the recent arrival of European timber in Australasian stores. These developments could threaten radiata pine's position in the domestic market and highlight the need for us to better understand our markets. We also need to increase our knowledge about wood variation and the drivers behind it, and how to apply this knowledge in the marketing and final use of timber from the forest onwards."

Segregation of raw material is seen as an immediate challenge for existing forests that are known to be highly variable in wood quality. "Several segregation tools are already available and others are under development," says forestry scientist, Dr Dave Cown. "Internationally, large integrated companies are well advanced in log segregation techniques either in the forest or the mill yard. In New Zealand,

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New genetic improvement technologies and the law's challenge to keep up

The High Court decision last month to quash the Environmental Protection Authority's (EPA) ruling that two new genetic improvement techniques do not create transgenic organisms does not affect Scion's current research programme to assess genetic modification technologies in the forest industry. However the ruling means that without change to the current Hazardous Substances and New Organisms (HSNO) Act, it will be much more difficult and expensive to use these technologies for research purposes and even more challenging to obtain commercial release. New Zealand industry and research leaders are no doubt actively reflecting on the strategic implications of this reduced access to productivity enhancing and biosecurity protection technology.

Scion asked the EPA to rule on new tools for genetic improvement – collectively called New Breeding Technologies – because international trends indicate they will be widely used in place of current genetic engineering approaches. This is because they do not require the introduction of foreign DNA and are more precise. As Barry Scott, Professor of Molecular Genetics at Massey University, noted, "The High Court decision will force the EPA to channel all applications involving new genetic technologies through the standard GMO application process even if the organisms being developed do not contain foreign DNA. The only route for exclusion of these technologies would be to change the regulations."

Dr Tony O'Connor, AgResearch Forage Improvement Science Group Leader observed, "The High Court has determined that newly developed methods for producing targeted mutations result in GMOs. These methods alter the existing genetic code of an organism without inserting DNA into the genome of a cell. The approach is more precise and scientifically predictable than the mutations induced by chemicals or radiation, commonly used in traditional plant breeding for over 60 years..... the High Court decision highlights that New Zealand's regulatory system on genetic modification is broken. Changes need to be made urgently; otherwise further innovation in New Zealand's genetic research will be severely stifled."

The decision seems likely to set New Zealand primary industry back. The HSNO Act was enacted in 1996 and changes in science since then have been enormous. Great strides have been made around the world in increasing the rate and precision of genetic improvement.

This situation contrasts with that in Australia where GM cotton and canola are increasingly popular amongst farmers. On 28 May, the West Australian Supreme Court ruled in a landmark decision that a farmer growing a lawful crop of GM canola had not contaminated a neighbouring organic certified farm. Indeed the Judge found that the decision of the Australian organic certifying bodies to decertify the organic farm had no legitimate contractual basis and had precipitated the farmer's loss of crop earnings. Meanwhile, a week earlier Federal Minister of Agriculture Barnaby Joyce publically criticised the South Australian Minister of Agriculture for participating in an anti-Monsanto protest march noting the GM debate had to move from the 'religious' to science evidence. He has endorsed the importance of GM technology to the future of Australian agriculture in several other fora.

This debate is very important because genetic improvement is critical to meeting the challenges of feeding 9 billion people with fewer land and water resources than today, adapting to climate change, and protecting plants from diseases and pests without the need for harmful chemicals. New Zealand examples of the latter include breeding kauri that are tolerant to dieback and reducing the wilding pine problem through sterile trees. These big challenges seem rarely to be considered by opponents of genetic improvement technologies despite most of them benefiting from GE food ingredients, textiles and medicines.

Rapid technological change is not limited to genetic technologies. Nanotechnology, assisted reproduction, cyber technology, predictive disease tests and stem cells for generating transplant organs come to mind. Each poses ethical dilemmas, requires public engagement and an understanding of their benefits and risks.

Legislation's inability to keep pace with technology is not new as was witnessed with, for example, the first steam locomotives and cars. Given technological innovation is accelerating, the 'legislation' gap can be expected to widen further unless we change the way laws are written. The solution according to some legal scholars is to craft legislation that is technology neutral and able to accommodate new science innovation fairly and effectively as it develops.

Forestry is fortunate it has leaders who publicly support the importance of undertaking field trials in containment in order to assess the benefits and risks of GM technology under tightly controlled conditions. They appreciate local trials (and associated visual evidence) will provide them the evidence for making a responsible decision on whether to apply to grow trees with, for example herbicide resistance or improved processing yields and product quality, in plantation forests.

The High Court ruling is not simply a declined right to use two improved non-transgenic breeding technologies – it gets to the heart of where New Zealand stands on technology that could profoundly improve the competitiveness and environmental performance of our primary industries.

Your thoughts on this matter or any other topic in this edition of *Scion Connections* will, as always, be most welcome.

Warren Parker, Chief Executive

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The opportunity exists to expand the market for locally grown eucalypts.

Exciting new possibilities for eucalypts

Eucalypts are a promising commercial plantation species. With their strength, hardness and attractive appearance, and in some species, durability, they provide timber for a range of markets from furniture and outdoor uses, to fibre for high quality papers.

However the popularity of growing eucalypts fluctuates. At present, the estimated 25,000 hectares of eucalypt forests in New Zealand comprises only about 1.4% of the commercial forest estate, yet New Zealand imports about $30 million of hardwood each year and even more in wooden furniture. The opportunity exists to expand the market for locally grown eucalypts as a sustainable alternative to these imported hardwoods.

Scion has been breeding and researching eucalypts for over 40 years, focusing mainly on the three species grown as short rotation fibre crops - *Eucalyptus fastigata*, *E. regnans* and *E. nitens*.

"Interest in growing eucalypts is cyclical depending on the price paid for wood chips here and internationally," says Scion tree breeder Toby Stovold. "It's therefore important to keep the breeding programme moving so there is a ready supply of good quality seed available for all three species. Our focus is on improving volume and the gains made each generation make the crop more profitable each time we deploy new seed."

Scion is also bringing in new technologies to help the breeding programme. "We DNA fingerprint all the new *E. nitens* selections to help limit inbreeding," says molecular breeding scientist Dr Emily Telfer. "This allows us to identify the seed parents, and limit their representation in the next generation. It also means we can continue to use open pollination strategies rather than costly, time-consuming controlled pollination.

"We have plans to further develop other eucalypt species for solid wood production, specifically the naturally durable *E. muelleriana* and *E. pilularis*, and produce improved seed based on existing provenance progeny trials. The aim is to complement the New Zealand Drylands Forest Initiative (NZDFI) programme. Selections from the *E. muelleriana* trials have already been incorporated into the NZDFI trials. *E. pilularis* is not a dryland species and its potential clearly lies in the warmer, wetter areas of the country such as Northland".

The key to growing eucalypts is matching the right species to the right site, and there are currently around 250 eucalypt species planted in New Zealand to choose from. Scion's breeding trials, permanent sample plots and models are all helping to increase the extent of commercially grown eucalypts for different purposes. These trials provide information about the adaptation of different eucalypt species to specific site types.

Eucalyptus fastigata is often referred to as the 'radiata' of eucalypts. It tolerates a wide range of sites and produces high volumes per hectare. Breeding trials are currently in the second and third generation resulting in greatly reduced forking and improved growth and form. Scion is working with forest tree seed company Proseed to build the supply of seed from improved third generation material.

Eucalyptus regnans is the world's tallest hardwood tree, able to grow at a rate of up to three metres per year. It was widely planted in New Zealand until the 1990s but planting was reduced due to tree health issues. Breeding for growth, form and health has continued however, using a simple single-population and selection based on disease tolerance. The breeding programme is currently entering its fourth generation. Most of these trees are more resistant to leader dieback and fungal health problems that plagued them earlier. Current stands are looking to set growth records with average heights of six metres in 30 months and the best trees at over nine metres. Seed will be available in 2016.

Eucalyptus nitens is the most advanced in breeding terms. Previous selection work for this species has resulted in trees well suited for New Zealand conditions as an appearance grade timber. Third generation trials have shown good results for diameter, volume, form and density with seed likely to be available in two years. *E. nitens* is prone to attack from the defoliating *Paropsis charybdis* (eucalypt tortoise beetle) however on-going research into biocontrol holds promise, particularly using a Tasmanian parasitoid wasp, *Eadya paropsidis*. A screening trial has been established that will help future deployment of material less likely to be attacked.

Next steps

Scion is working with the forestry industry to develop an exciting new partnership for growing and processing eucalypts. The initiative includes these species with the aim of creating new value chains at a regional scale. The proposal will investigate how to increase certainty of growing the right species on the right site, in what region and ultimately producing maps for growers and processors alike. In addition, we intend to identify what new products can be made that match with market requirements, while extracting more product of higher value from each tree. This initiative is expected to be running by Christmas 2014. Enquires are welcome.

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The growing desire to provide ecosystem services will likely drive diversification.

Choosing the right tree for the job

Forest growers are becoming increasingly aware of the ecosystem services and non-market values that forests provide.

Based on regular engagement with growers and landowners, our scientists realise many are considering planting indigenous and plantation species other than radiata pine in the belief that they are better suited to provide both market and non-market values. These perceptions will influence the choice of tree species planted in future plantations, with the risk they may not deliver the ecosystem services expected.

To gain a better understanding of growers' opinions and how they may shape future plantation forestry, our scientists surveyed a cross-section of forestry stakeholders to identify which tree attributes, from a list of 15, they believed contributed to five ecosystem services - amenity value, bioenergy production, carbon capture, diversity of native habitat, and erosion control/water quality. Commercially relevant qualities such as growth rate, disease resistance and timber quality were included in the list, as were qualities such as attractiveness to birds, fire tolerance, shade tolerance and nutrient demand.

Participants were then asked to identify which tree species they believed possessed those attributes from a selection of 22 species, chosen for their forestry-based attributes such as growth rate, wood characteristics, water interception and their ability to adapt to climate change. Five indigenous species - kauri, totara, pohutukawa, kānuka and beech – were also included as their natural geological range matched the land available for forestry.

The survey was targeted at individuals who make or influence decisions around forest management and species selection, and was promoted through industry and public channels, generating 139 responses.

"We compared the results of the survey with data from current growth, physiological and ecological studies," says microbial ecologist Dr Simeon Smaill. "The survey showed that many of our participants hold inaccurate assumptions about the suitability of certain species to provide ecosystem services.

"For example, many participants considered that slow growth was a relatively important attribute for the provision of amenity and diversity services. However, without significant management interventions, slow growing species will generally be outcompeted by weeds.

"What was more interesting was the high ranking - in terms of providing specific ecosystem services - of one species, *Sequoia sempervirens*, across all five ecosystem services."

There is some evidence to support *S. sempervirens'* (Californian coast redwood) position in the top spot. Its robust health and ability to tolerate diverse conditions makes it well suited for erosion prone hill country. Its suitability for carbon capture and biomass production for bioenergy is also based on such things as good growth rate, wood density and its ability to coppice. However there are no data describing its ability to provide a habitat for New Zealand native plants and insects and enhancing biodiversity.

Although current markets will likely dictate radiata pine continues to be a dominant plantation species, the growing desire to provide ecosystem services will likely drive increased diversification in some regions.

Many landowners are now appreciating the biodiversity and amenity values that native and exotic forest species can provide," says Simeon. "This survey highlighted that the accuracy of forest growers' perceptions varies greatly, and is biased towards species that are familiar but not necessarily better understood.

"It also indicates a need for us, as scientists, to engage more with forest stakeholders about ecosystem services and non-market values so that people can get what they want from their forests in the future."

Protecting our water through forestry

Exploring the link between the forest ecosystem and the services it provides, and its contribution to the economy and to people's health and wellbeing, is the subject of Scion's annual Forest Ecosystems Services Forum.

This year's forum focused on the role forests play in providing freshwater resources and ecosystem services to New Zealand such as water quality, water yield, recreation and biodiversity.

When it comes to freshwater, forests provide a range of ecosystem services such as providing natural filtration and storage systems that help maintain the quality of our water. Some forests provide drinking water to nearby towns, or are a source of clean water for other productive land uses. They also provide protection from natural hazards such as flooding and soil erosion.

According to Dr Peter Clinton, Science Leader for Forest Systems, the freshwater and riparian habitats found in forests are home to some of the most diverse ecosystems in New Zealand.

"People value the aesthetics of these areas - they are used for recreational and educational purposes and are enjoyed and valued by both Kiwis and overseas visitors. Many of these benefits are not recognised or are undervalued under the current economic environment."

However, there are trade-offs to be considered. Forests can reduce water yield, particularly in drier areas. In the case of planted forests, water quality and freshwater ecosystems can be compromised during harvesting and contribute to localised flooding, although the effects are usually short-term.

"Usually these factors are more than compensated for by the positive freshwater ecosystem services that forests provide," says Peter. "Land productivity is usually measured in economic terms and does not always include the benefits of the ecosystem services it provides. Including these benefits would allow the comparison of different land uses, and optimised catchment land management for economic return as well as for environmental and social performance."

Scion's annual forum provides the opportunity for scientists, foresters and other interested parties to share their latest research and help shape the direction of future ecosystem services research. The forestry industry has a target of increasing the value of New Zealand forest exports to $12 billion by 2022, and as Peter says "This increased intensification must be within environmental limits to protect our access to international markets and to ensure our forests continue to deliver ecosystem services such as high water quality".

(Presentations available on the past events section of our website)

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Increased intensification must be within environmental limits.

Is wood quality still relevant?

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smaller organisations need to ensure that the benefits outweigh the costs, particularly when it comes to the additional skid space required and the costs associated with this. It's just not practical on many New Zealand sites due to conditions such as slope and harvest volumes from small woodlots.

"While most wood quality features are strongly heritable, they compete in the breeding programme with other traits such as volume and disease resistance. It is also a disincentive for growers that the benefits accrue to others further down the value chain."

According to Dr John Butcher, CEO of the Radiata Pine Breeding Company, breeding for volume is easy to justify, but improved wood quality is more difficult to validate and growers are not getting clear signals from processors about what the desirable traits are. "What was conclusive from these workshops was that the industry must not lose focus on the quality of our wood products," he says.

While forest management models can be used to address simple quality issues like wood density and stiffness, more complex characteristics such as those influencing stability and appearance are difficult because of gaps in our knowledge. Scion aims to address some of these issues as part of the 'Growing Confidence in Forestry's Future' research programme. The programme focuses on making improvements throughout the forest growing cycle for both current and future forests that will boost profitability under intensified management regimes, while trying to improve the uniformity and consistency of wood properties.

What was conclusive from both workshops is that there is unrealised opportunity to create more value from our forest resources, and Scion is in the process of exploring this proposition through better communications between all sectors of the forest industry.

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Bioplastics are a rapidly growing market.

Investment in bioplastics research pays off

Bioplastics are a small but rapidly growing niche that currently represents about 1% of the global plastics market. Their use is expected to grow by over 10% per year, with the estimated global market expected to be more than 12 million tonnes per year by 2020.

"Legislation, consumer demand for sustainable materials and making better use of our natural resources are driving the development of products made from renewable resources," says Dr Alan Fernyhough, Science Leader for Biopolymer and Chemical Technologies. "Improving the properties of bioplastics and finding new ways to implement them into our lives and businesses also reduces our dependency on petrochemicals.

"Manufacturers are demanding renewable materials that offer more functionality – such as being stronger, stiffer and lighter weight, heat and water resistant, more durable, and flame retardant. These materials need to prove their 'green' credentials and be free from harmful components. They also need to be produced cost-effectively."

Scion saw the potential of bioplastics over ten years ago and invested in the facilities and capability to support the plastics manufacturing sector.

"Our research takes a different approach to many countries in how we use and develop bioplastics and related technologies," says Alan. "We have developed expertise in extrusion processing of biomass, bioplastics, novel bio-based additives and fibre addition."

Recycling renewable resources

Our latest research shows that plastics reinforced with MDF fibre (licenced to Sonae Indústria as Woodforce) can be recycled many times with little change to their mechanical properties. Woodforce is an engineered diced wood fibre pellet developed by Scion that is used to reinforce thermoplastic polymers in the same way as short glass fibre and other natural fibres such as flax.

Polypropylene reinforced with MDF, flax and short glass fibres were recycled six times through Scion's extrusion and injection moulding pilot plant and then tested for strength, stiffness and impact strength. The MDF composite fared the best, retaining on average, 87% of its original properties in comparison to flax (72%) and glass (59%). The MDF fibres also retained most of their original fibre length, and therefore strength, whereas flax and glass fibres were more prone to degrading or breaking. In addition, MDF fibres have a lower density than glass fibres making them an attractive alternative for use in materials where weight is important. These attributes may help MDF fibre plastic composites be more appealing to plastic processors and recyclers, and assure their place in future markets.

Computer simulation aids industrial extrusion

Computer modelling was used to help find the right extrusion parameters for compounding Woodforce fibres with a thermoplastic. Parameters such as extruder screw configuration, pressure, melt temperature and processing energy affect how the fibres are dispersed throughout the resin, the length of the fibres, and the final appearance of the composite.

Modelling assisted in the scale-up from Scion's extrusion pilot plant to an industrial level. Industrial compounding trials were then run at a commercial scale in association with Sonae Indústria.

Biodegradation

Scion's new biodegradation facility measures the composting of materials like bioplastics by replicating conditions used in typical industrial composters. The facility is unique to New Zealand and one of only two in Australasia. It was designed and built to measure the breakdown of materials to international composting standards such as the European Compostable Packaging standard EN 13432.

The facility is used to tailor the composting of newly developed biomaterials such as the biospife. The facility can also be modified to measure the breakdown of any material in any medium such as soil or aquatic environments. The biodegradation facility is commercially available to clients from packaging, plastics and export industries.

Visit Scion on YouTube for a closer view.

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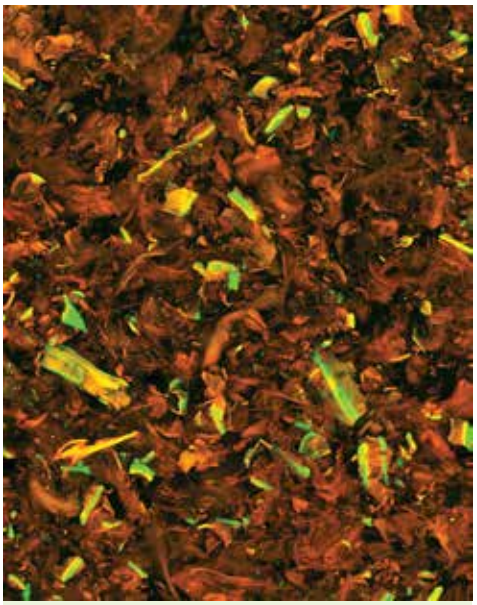

Wood-based biofuel substrate. Orange areas are porous while green areas are non-porous.

Under the microscope

A picture paints a thousand words, as the saying goes, and no more so than images captured by Dr Lloyd Donaldson through Scion's confocal microscope. The confocal microscope is widely used to characterise the structure of biomaterials, like wood and wood-derived products. It generates high resolution colour images in three dimensions using either the natural fluorescence of a subject or light emitted as a result of staining, making it possible to study minute objects within a sample.

These images help our scientists understand the structure of wood, fibres, plant tissues, fungi, plastics, adhesives and coatings. They also provide valuable insights into product characteristics and performance, such as the cell wall components in a range of different plant species and wood formation at the molecular level.

The microscope can also perform complicated experiments such as the measurement of molecular interactions at nanoscale. Such techniques are used by our scientists to help develop plant-based biomaterials.

The expertise Scion offers in microscopy and image analysis of wood and plant fibres is internationally recognised. Lloyd's images have recently been selected for the covers of three major international science journals, *Plant Molecular Biology*, *The Plant Journal*, and *Biotechnology & Bioengineering*.

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Protecting your product with better packaging

Scion's new coolroom facility has been purpose built to test how corrugated boxes perform when exposed to fluctuating humidity, which is what they experience during distribution in the chilled supply chain.

The coolroom has a special twin wall design to keep the temperature constant at 4°C (and at higher temperatures if required) and to accurately cycle relative humidity between 50%-90%. The changing humidity causes the paper to contract and expand. Compression creep tests can be conducted in the coolroom to capture the strain profile of a box or to measure box lifetime.

Using this new facility combined with the wide range of existing paper and board testing equipment, Scion's packaging team, led by Lou Sherman, can now start to understand the relationship between paper performance, corrugated board characteristics and box lifetime. They also work with a range of materials (including plastics, bioplastics and hybrid material) to design innovative packaging solutions, and optimise conventional materials using such things as functional coatings and additives.

Our latest advances in packaging solutions and test facilities were promoted at our recent 'Ahead of the pack' workshop, which was aimed at updating packaging suppliers and users with the latest global trends in packaging and bioplastics. Over 40 people attended.

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Drs Stefanie Gutschmidt and Richard Parker with the tree-to-tree robot.

Tree robot scoops national award

Scion's remote controlled tree-to-tree robot (*Scion Connections* issue 11, March 2014) has been recognised with a national engineering award from the Institution of Professional Engineers (IPENZ).

Developer, Senior Scientist Dr Richard Parker, has been working on the project in partnership with the University of Canterbury. With guidance from Professor XiaoQi Chen and Dr Stefanie Gutschmidt, Richard co-supervised four engineering students from the university to design and create a working prototype of the device. The students George Wareing, Sean Bayley, Scott Paulin and Thomas Gilbert received the IPENZ Rey Meyer Medal in March for the project, which is awarded to an individual or group of engineering students for best final-year project.

The device has been designed to improve the safety of steepland forestry by providing a mobility platform that can eventually be used to perform tasks.

"Our aim is to develop a whole family of tree-to-tree robots which can perform productive tasks in the forest, such as felling, pruning and measuring trees," says Richard. "Humans will still need to oversee their operation and maintenance, but they will be able to do so at a safe distance from hazardous, steepland operations."

The tree robot has been developed with funding from Scion, Future Forests Research and the Ministry for Primary Industries' Primary Growth Partnership programme.

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Scion bids farewell to Trevor Stuthridge

Dr Trevor Stuthridge, General Manager for Sustainable Design, leaves Scion to take up the position of Executive Vice President for FPInnovations in Vancouver, Canada, on 1 July. Trevor founded Scion's Sustainable Design group which has provided innovation in forest management, wood processing, pulp and paper and sustainability, specialising in clean technologies, forest industry informatics and value chain optimisation. He has also been instrumental in developing significant commercial opportunities in the past five years, including New Zealand's largest lignocellulosic-to-biofuels project, the sale of Scion's ATLAS software business and TERAX™, an organic waste deconstruction technology.

Trevor has been working closely with the Canadian research and forest sectors for over 20 years. Since 2006, he has served as an adjunct professor at the University of Toronto, and has previously completed a sabbatical at FPInnovations' Pulp, Paper and BioProducts division.

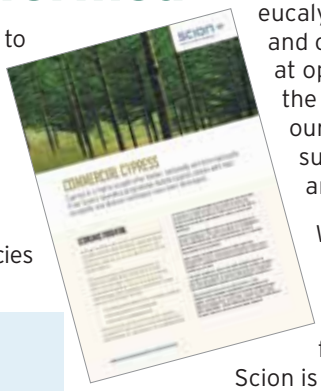
"This is an exciting opportunity to transfer skills and experience gained at Scion into a larger forestry and wood processing research organisation," says Trevor. "FPInnovations offers on-going opportunities to strengthen ties between Scion and other world-leading research organisations in order to create synergistic benefits to the broader industry sectors they serve. Some of these collaborations are already in progress and offer enormous leverage for New Zealand.

"I look forward to helping facilitate opportunities for researchers at Scion and our industry stakeholders to work closely with FPInnovations in the many areas of mutual interest I know we share."

Keeping you informed

Scion produces a range of resources to keep you up to date on our current research, and provide you with information about our science and technology capabilities.

Our latest series of factsheets illustrate the work we are doing to develop alternative commercial species to radiata pine. This research includes exotics such as eucalypts, coast redwoods and cypress. It also looks at opportunities to grow the economic value from our indigenous species such as totara, kauri and manuka.



With eucalypt plantations being an important addition to our commercial forestry industry, Scion is employing biological control methods to protect these valuable resources from defoliating pests such as the gum leaf skeletoniser and the eucalyptus tortoise beetle.

Also on the production line is a series about the 'Healthy Trees, Healthy Future' research programme which is aimed at protecting our primary industries from new and existing *Phytophthora* diseases.

These and other publications are available for you to download at www.scionresearch.com/publications.

New website launched to support new look forestry

Scion has launched a new website to provide essential information for the six-year Growing Confidence in Forestry's Future (GCFF) research programme. The programme, led by Dr Peter Clinton, is a joint initiative between Scion, Forest Growers' Levy Trust and the Ministry of Business, Innovation and Employment.

The website will be updated regularly with events, a newsletter and research updates. You can 'subscribe' to our six-monthly GCFF newsletters and announcements of upcoming events.

Visit www.scionresearch.com/gcff

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