



The CutoverCam emits high frequency video of ground operations back to the hauler operator.

New technologies for improved forest safety

Three new harvesting technologies developed by Scion, in conjunction with industry, will help improve workplace safety in forestry.

Sadly, there have been six fatalities in forestry this year alone, well above the national average. The Ministry of Business, Innovation and Employment (MBIE) is working with forest owners and workers to implement a new code of practice aimed at raising the bar for workplace safety, and the industry itself has identified the long-term solution is for increased mechanisation.

Developed in response to this demand, our forest harvesting technologies are making significant inroads into helping the country's third largest export earner achieve these goals, and reduce its workplace injury toll.

Planning for greater certainty

The Cable Harvest Planning System (CHPS), developed by ATLAS Technology in conjunction with Geographic Business

Solutions, is a modern software system that breathes new life into tried-and-true physics.

"Payload analysis for cable harvesting is not new," says Jeremy Snook, business analyst at ATLAS. "While similar systems have been developed in the past, CHPS is the first to be directly integrated into GIS - geospatial software which is one of the forest manager's core tools. This provides easy access to detailed information about the terrain, while allowing seamless transition to other day-to-day forest management activities such as harvesting, as well as log yield information.

"Much of the forest due for harvesting was planted in the early 1990s on steep, erosion prone land. It's too steep to use ground-based mechanical harvesting equipment so must be harvested using cable haulers. Planning these harvesting operations is

challenging and ensuring the safety of the ground crew is paramount."

Hauler tailholds need to be positioned for maximum hauler reach and payload. Repositioning a tower is costly particularly on combinations of steep terrain and some soils. CHPS uses geospatial terrain data (for example, derived from LiDAR - refer page 3), hauler and rigging characteristics, such as tower height and cable breaking strain, and then applies robust, well established science to determine the best positioning of the tailholds to achieve maximum payload.

"CHPS translates rich terrain data into usable information, equipping contractors with a better knowledge of any constraints they may be faced with, such as where hauler vision will be restricted. This helps forest managers and harvesting contractors find optimal locations for the hauler pad and identify solutions along extraction corridors, plan upfront for any safety issues and help them set contract rates.

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Growing confidence in forestry's future

The big news for Scion this quarter was the Government's announcement of Ministry of Business, Innovation and Employment (MBIE) funding to support forest industry research. This is significant because current MBIE funding of Scion's forest growing research, managed through Future Forests Research, ends on 30 September. We are therefore very pleased to have been awarded \$20.25 million over six years to develop with industry a precision forestry approach to radiata pine and \$10.05 million to accelerate research into plant diseases that can seriously harm radiata pine, kauri and horticultural tree species.

The larger project, involving some \$4.9 million per year with industry co-funding, is named "Growing confidence in forestry's future". Here the goal is to make *Pinus radiata* forests more productive, sustainable and profitable through precision technology, improved environmental practices and management, and better use of genetic resources. The research programme, developed with forest growers, will integrate the latest advances in remote sensor technology, tree physiology, genetics, forest ecology and complex problem-solving. Targets include doubling tree growth while improving wood quality and consistency; and assuring international markets that New Zealand's intensified forest management practices are environmentally and socially sustainable.

Importantly, these outcomes are consistent with the aspirations of Māori who wish to use their forest assets to build greater economic wealth and more employment for their people and strengthen Mātauranga Māori.

Scion Science Leaders Drs Peter Clinton and John Moore will lead the project with input from other New Zealand and international research and industry experts. An important feature of the work will be a close working relationship with forest growers to ensure the research outputs remain well-targeted to user needs and are readily and quickly adopted.

Scion will also lead the second large new research programme to protect New Zealand's primary industries and conservation estates from current and future diseases. The focus will be on *Phytophthora* diseases, which are a huge biosecurity challenge worldwide owing to the range of plants they affect, rapid global spread, sweeping impacts and high costs to manage.

New Zealand currently confronts challenges with three major *Phytophthora* diseases of trees: kauri dieback, red needle cast of radiata pine, and crown and collar rots of apples. The project will help mitigate this disease risk through plant breeding to improve disease resistance, disease management and fundamental knowledge of tree defence mechanisms to *Phytophthora* species.

Led by Dr Nari Williams, the project will bring together key New Zealand researchers and international specialists

working in the management of *Phytophthora* pathogens, and will involve conservation managers, forestry and horticultural industries. This project will build New Zealand's capacity to respond to current and emerging *Phytophthora* threats, and will see New Zealand become a world leader in addressing the complex issues of *Phytophthora* management in trees.

We are delighted too that the Government will invest \$2.5 million over five years to the Radiata Pine Breeding Company (RPBC) to produce new technologies that will reduce the time it takes to breed and commercially plant improved pine trees. RPBC has formed a partnership between forestry organisations, Scion and the University of Canterbury to research and develop the new technologies. This programme will draw on pioneering work to sequence the radiata pine genome, the latest knowledge (and techniques) about genomic selection and findings from the "Growing confidence in forestry's future" programme.

In the high value manufacturing portfolio we are pleased that the Biopolymer Network Ltd (BPN) was awarded \$17 million by MBIE. A joint venture between Scion, AgResearch and Plant and Food Research, BPN will use this funding to continue its ground-breaking work in developing resins and foams from biological materials and a green processing approach that enhances the performance of fibres and polymers.

Working with our research collaborators and industry on the new programmes commences on 1 October. We are also exploring alternative funding to sustain our important research into alternative species such as Douglas-fir, cypresses, eucalypts and indigenous species such as kauri, totara and red beech.

We look forward to seeing the positive impact of the new research programmes on the profitability and health of New Zealand planted forests and in encouraging the establishment of larger planted forest estates to meet growing global demand for sustainably produced softwoods.

If you have any queries about the new MBIE programmes or other articles in this edition of *Scion Connections* please contact me or one of the identified staff directly.

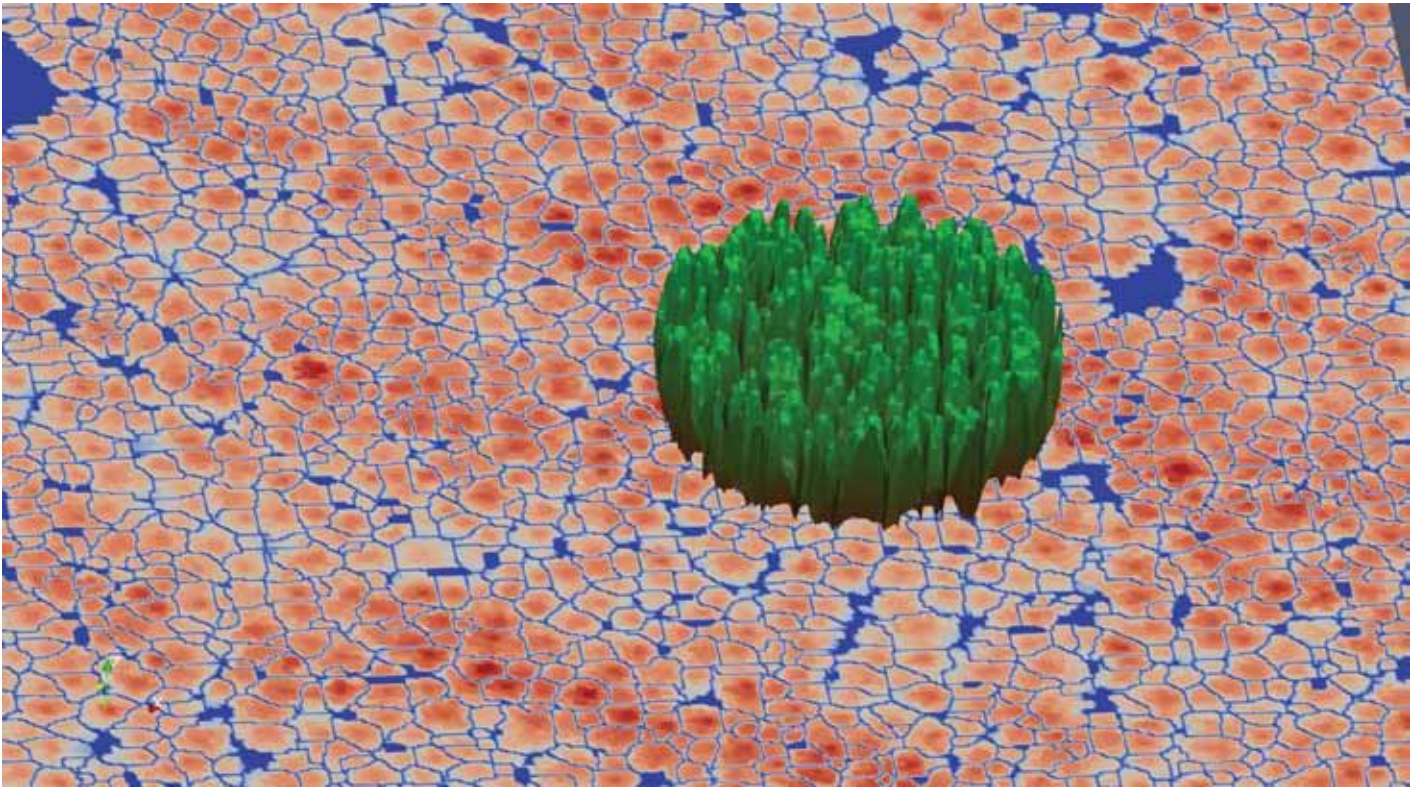
Clarification. In the previous issue of Connections (# 8), we stated that approximately 40 per cent of New Zealand's planted forests would be owned by Māori at the conclusion of the Waitangi Treaty settlements. This should have read "approximately 40 per cent of forested land including some planted forests." We apologise for any misunderstanding this may have caused.



Warren Parker, Chief Executive

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Remote sensing technologies will make it possible to manage commercial forests from afar.

A bird's eye approach to precision forest management

Remote sensing technology, such as LiDAR (Light Detection and Ranging) has had a huge impact on forest management. LiDAR technology uses reflected laser beam emitted from sensors mounted on planes to provide accurate ground mapping and data on stand variables, such as height, volume, basal area and stocking that ultimately may make it possible for foresters to manage vast commercial forests from afar.

Two breakthrough technologies developed recently by Scion's resource assessment specialists can translate this valuable LiDAR data into usable information. Tapping into this bird's eye approach will enable foresters to do such things as measure the maturity and density of a stand, and reliably count trees, making it possible to predict key stand metrics and plan supply chain logistics accurately from the office.

The resource assessment team, led by Dr Michael Watt, has worked with industry partners Timberlands Ltd, Silmetra and Interpine to develop a methodology that can translate LiDAR data into area-based metrics that can be directly used in existing software to improve the accuracy of assessing stand resources.

Timberlands Ltd plans to implement the technology as a resource assessment tool and will be acquiring LiDAR data for all of Kaingaroa forest, which constitutes about 10 per cent of the national estate.

"The use of LiDAR is likely to considerably reduce the number of plots required for inventory purposes," says Michael. "And it's also likely to result in precision gains, which may help reduce costs for forest managers.

"Timberland's application of this technology is liable to expedite the uptake

of LiDAR throughout the forest industry in New Zealand."

In a step further, resource specialist and software developer, David Pont, has refined the methodology to detect, delineate and count individual trees. The Individual Tree Detection (ITD) software can generate individual tree metrics and maps showing spatial variation in tree stocking, and allows forest managers to accurately predict stocking and tree dimensions. This level of detail has not been achievable until now.

"The use of LiDAR is likely to considerably reduce the number of plots required for inventory purposes. And it's also likely to result in precision gains, which may help reduce costs for forest managers."

"Reliably identifying individual trees using remote sensing has been an elusive goal for the global forestry industry for years, and we have achieved it," says David.

While the resource assessment and the ITD technologies both use the same LiDAR data, their application of it differs. As David explains, "ITD software can provide a

greater level of detail that is not available using conventional remote sensing technology."

Tests have shown the ITD software can count trees in a stand to within a 5 per cent margin of error. On-going research is looking into the utility of ITD to predict log grade and wood quality.

Individual tree detection will also provide valuable input to a planned phenotyping platform for future research into genetics, tree breeding and forest management; critical for supporting the forest industry's productivity enhancement goal.

"These technologies are ideal for New Zealand conditions where there is predominantly a single species grown commercially," says David. "This is not the case internationally where mixed species make it difficult to remotely assess resources. However, it is likely our software can be adapted to solve this issue for global clients."

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Kauri dieback disease may potentially wipe out whole populations of kauri.

Microscopic monsters take on mighty forest giants

The graceful, iconic kauri, *Agathis australis*, comfortably placed in the top echelon of the world's mightiest trees, is at risk of being toppled by a microscopic monster.

Kauri dieback, or *Phytophthora taxon agathis* (PTA), is a fungus-like disease in New Zealand that is attacking the roots of kauri, slowly destroying their ability to draw water and nutrients from the soil. The disease hits below the surface of the soil; once the trees show outward signs of the disease, it's too late to save. However, work has shown the disease may be managed using chemical techniques.

"Kauri dieback is a devastating disease," says forest pathologist Dr Peter Scott who is planning to screen trees for natural resistance. "It may potentially wipe out whole populations of kauri. Many infected trees have died and will likely die in the near future - thousands have succumbed in the past decade.

"Kauri is a cultural icon to many people and we consider it an honour to be involved in this project," says Peter. "We're looking

for trees that show natural resistance so we can breed from them and eventually revegetate affected sites.

"Kauri is a cultural icon to many people and we consider it an honour to be involved in this project. We're looking for trees that show natural resistance so we can breed from them and eventually revegetate affected sites."

"Each population of kauri is distinct and some more susceptible to the disease than others. At this stage, we know little about the disease, or how long it takes for a tree to start showing signs of infection - in a tree that lives for over 1,000 years, its

academic if it's two or ten. There may be one healthy looking tree in a population of sick trees, and the perception is that this tree is okay, however it may die in ten years' time, we just don't know.

Scion has recently received \$10 million funding from MBIE over six years, to help tackle the problem for New Zealand and lay the foundation for genus-wide management strategies.

"The first signs of the disease are often bleeding lesions on the trunk, yellowing and thinning of the canopy and dead branches, but again, this can differ between sites. It's just devastating seeing a 900 year old tree turn yellow and die."



Sap bleeding lesions on kauri trunk.

According to Peter, public perception will be vital to the success of the project. "It's important for us to engage with the public on the severity of this disease and its implications, and we're hosting a free public symposium in November to facilitate this. Because the disease is soil based, it can spread through the transfer of any organic matter - on people, bikes, through animals such as pigs, and the pig hunters themselves - even unwittingly by transferring plants, or any plant based organic matter from one location to another."

In addition to kauri dieback disease, there are two other major *Phytophthora* diseases in New Zealand that have a serious impact on our primary industries - red needle

cast of radiata pine, and crown and collar rots of apples. Worldwide, there are more than 120 species known to cause plant diseases. The *Phytophthora* fungi pose a huge global biosecurity challenge due to the range of plants they affect, their rapid global spread and devastating impact, and the high costs associated with managing them.

Scion has recently received \$10 million funding from MBIE over six years, to help tackle the problem for New Zealand and lay the foundation for genus-wide management strategies. The project brings together Scion, Auckland Council, DOC, Landcare Research and international specialists, and will potentially see New Zealand become a world leader in the management of *Phytophthora* in trees.

"We need to tackle the issue from many different angles in order to manage the problem," says Dr Nari Williams, forest pathologist and coordinator of the *Phytophthora* research project. "Scion is

a leader in plant breeding, and this will play a key role in the *Phytophthora* research.

"We need to tackle the issue from many different angles in order to manage the problem," says Dr Nari Williams, forest pathologist and coordinator of the *Phytophthora* research project.

"Breeding lines of radiata pine, kauri and apples will be screened against a range of *Phytophthora* species. Susceptible and tolerant lines of each host plant will be selected and the interaction between these and the *Phytophthora* species characterised at a genetic and metabolic level. This information will help us understand the mechanisms of disease resistance and accelerate screening programmes against a range of pathogen attacks in each host so we can establish efficient controls.

"Breeding for resistance to individual *Phytophthora* species has been successful with other trees, such as the jarrah forests in Western Australia and Lawson Cypress. We'll be breeding for resistance to a whole suite of *Phytophthora* species, and using resistant material to revegetate populations and for viable, commercial forestry."

As for our beloved kauri, Nari says it's not just the trees themselves that we need to restore to good health - it's a whole ecosystem.

"Kauri is a keystone species and so many other plants and wild life thrive within the kauri forests."

For further information:

Free public symposium, 30 November (see page 8)

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New technologies for improved forest safety

(Continued from Page 1)

"This provides greater certainty and more informed risk management for contractors and forest growers."

Grappling with safety issues

Breaking-out is responsible for an estimated 40 per cent of forestry-related accidents. Breaker-outs, crew members who attach cables to felled trees ready for extraction and who shift hauler cables once a corridor of trees has been extracted, are continuously wrestling heavy chains and hooks, often on steep, debris-strewn land. They are constantly at risk from falling trees, swinging stems and dislodged debris.

Scion, with Future Forests Research (FFR) and commercial partner Alpine Logging, have built a prototype hydraulic-based hauler grapple designed specifically for New Zealand conditions that will make grapple yarding technology more accessible for steepland, high risk extraction. Designed to work on both swing and tower haulers, the grapple's improved carriage design and control will enable more contractors to adopt the technology.

"The grapple builds hydraulic pressure as it moves up and down the cables, which is used to manipulate the grapple arms," says Spencer Hill, research leader for harvesting and logistics. "The non-motorised operating system makes it lighter, low cost and cheaper to run than conventional, motorised models.



The hydraulic-based hauler grapple.

"The grapple can be controlled remotely by the hauler operator. Because it can be rotated it can pick up the trees better, and pull trees out of gullies where it's simply too dangerous for people. This ultimately means a far safer hauler operation."

Zooming in on operations

Also designed with safety at the forefront, is the innovative hauler vision system, the CutoverCam, developed by Scion for FFR.

"Steep terrain often makes it difficult for the hauler to get a clear view of the break-out zone," says Spencer. "The CutoverCam

uses wireless security camera technology to emit high frequency video of ground operations, and the breaker-outs, back to the hauler operator.

"The hauler can operate the camera remotely - pan, tilt and zoom in, to gain a clear view of ground operations from the screen mounted in the cab. Instead of relying on hand held radios and talkie tooters to signal what's happening, the hauler can see directly what's going on and respond to that."

"The CutoverCam uses wireless security camera technology to emit high frequency video of ground operations, and the breaker-outs, back to the hauler operator."

Recent feasibility studies show the camera is beneficial in grapple and rigging positioning, heightening response time to problems, and avoiding stem hang-ups and breakage on stumps thus reducing maintenance costs.

For further information:

CHPS was developed by Geographic Business Solutions with assistance from Scion. www.cableharvesting.com

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Forest fibre is a large scale option for the production of bio-based industrial products in New Zealand.

Sharing our knowledge to secure our future

Science is playing a progressively larger role in unravelling the many complex and interlinked challenges facing global communities.

Scion's management and senior scientists participate in a number of international collaborations aimed at addressing some of these challenges. One such collaboration is the Knowledge Based Bio-Economy Forum (KBBE), a formal cooperation between the European Commission, Canada, Australia and New Zealand to foster international cooperation in four key areas of research - food and health, bio-based industrial products, fisheries and aquaculture, and sustainable agriculture. The next forum meeting is scheduled for Australia in October 2013.

In each country there is a leader for each research theme who coordinates and develops collaborative research within that area.

"The forum is driven by the need to address global challenges," says Dr Elspeth MacRae, General Manager Manufacturing and Bioproducts and New Zealand's leader for bio-based industrial products on the KBBE Forum. "Scientists are working together to find ways to help address such things as the security of our food supply in a changing climate, and to investigate new economic opportunities including lignocellulosic biorefineries and bio-based substitutes for petroleum and other declining resources.

"Last year we conducted an analysis for MBIE, and assembled a roadmap of the New Zealand bio-based industrial products landscape, outlining any gaps for the industry moving forward," says Elspeth.

"This included current research and companies associated with bio-materials.

"Our focus is on harmonising standards, plant-based oils for biorefineries, natural fibre composites and producing chemicals and energy from renewable resources. Forest fibre in particular, is a large scale option for New Zealand.

"Much of the research we are doing here at Scion in the manufacturing and bioproducts area fits well with this KBBE initiative. We are doing some exciting work on wood fibres for use in bioplastics, and renewable chemicals used in bio-adhesives and bio-resins. Our license with Sonae Indústria Group for our wood fibre dice technology, or Woodforce, is a good example of this."

"Our focus is on harmonising standards, plant-based oils for biorefineries, natural fibre composites and producing chemicals and energy from renewable resources."

According to Biopolymer and Chemicals Science Leader Dr Alan Fernyhough, who attended a KBBE workshop on natural fibres and composites in Montreal in July with materials scientist Marie Joo Le Guen, the growth of composites continues unabated.

"The workshop was a very useful day of talks and discussions. Many of the

international teams are working on similar developments. There is work being done on using wood and other natural fibres in composites, nanofibre composites, and breaking down lignin and using it in resins, or making other bioproducts such as bioadhesives.

"Another example is enzyme retting of natural fibres. This is where enzymes are used to separate fibre from non-fibre tissue in stems, which is proving particularly valuable for hemp and flax.

"What became apparent from our discussions was that there were areas of concern common to all countries that we need to work together in solving. For example, the secure and sustainable supply of quality feedstock, and the logistics of processing plants - location, costs, integration with biorefineries.

"Unification on standards and protocols was another important theme, especially with increasing globalisation. For New Zealand, the emphasis was placed on high performance in thermoplastic composites - both in wood and non-wood, and the variability in fibre sources.

"Scion is already doing a lot of work in this area, particularly with composites, biofoams, lignin bioplastics, recyclability and 3D printing."

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Eucalyptus leaf beetle.

Fighting the invaders

Our forest protection team has been working with Ministry for Primary Industries (MPI) to eradicate the spread of the Eucalyptus leaf beetle, *Paropsisterna beata*, a recent invader of New Zealand forests. The beetle defoliates tree canopy, reducing growth rate and subsequent pulp production. If left unchecked, MPI estimates it could potentially cost the pulp industry millions of dollars annually in lost production.



The team has developed an effective spray programme suitable to the terrain and canopy conditions, using the AGDISP spray deposition model (see following article). The beetle is restricted to a small valley near Upper Hutt and scientists expect it to be eradicated after the spring treatment.

Our diagnostic laboratory also identified a new to New Zealand insect that has potential to be another significant pest of eucalypts. The bronze bug,



Thaumastocoris peregrinus, is a sap feeder causing leaf discoloration, or 'winter bronzing', which can lead to premature leaf drop and branch death. Potential hosts

of the bug include over 30 eucalypt species; the most severely affected to date appears to be the popular amenity tree, *Eucalyptus nicholi*. Scion is reviewing biological control options and continuing to research the bug's ecology.

Scion Innovation Park

Scion has been allocated \$2.5 million by Bay of Plenty Regional Council for the development of an 'Innovation Centre' at our Rotorua campus' Innovation Park. The funding is part of the council's Regional Infrastructure Fund to support economic development in the region.

The centre will be a hub for innovative companies in forestry related products and services with the aim of fostering collaboration and innovation between similar businesses and with Scion.

"The Innovation Park is part of a wider vision to establish Rotorua as a 'forest industry centre of excellence'."

"The centre is part of the economic growth initiative for the Bay of Plenty," says Chief Executive Warren Parker. "We will also draw on networks, such as Grow Rotorua, to attract firms with fresh talent and new technologies. We will also establish a formal link with Waikato Innovation Park, one of the most successful in New Zealand, and deepen our collaboration with the University of Waikato and Waiariki Institute of Technology.

"The Innovation Park is part of a wider vision to establish Rotorua as a 'forest industry centre of excellence'."

The new building for the centre is due to be completed by January 2015, and aims to support the creation of thousands of jobs, both directly and through innovation and the development of new processing facilities. It will also help increase export earnings from the forestry industry in the Bay of Plenty by up to \$1 billion.

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Keeping track of spray applications

Scion's new precision track sprayer provides a novel approach to conducting spray deposition research.

The sprayer boom can currently reach speeds of up to 18 km/hr, with the 12 metre track able to be extended in the future to allow for greater speeds that better represent aerial spray applications. The track sprayer gives scientists the ability to adjust spray release speed, droplet size, canopy type and density. Using dye tracers and artificial collectors, scientists can determine droplet penetration and spray deposition in and on plant canopies.



Measuring spray droplets.

"In addition, we use images captured by a fish eye lens to quantify and characterise plant canopies," says Stefan Gous, pest management and application technology scientist. "Spray droplet spectra are measured by either a laser diffraction particle size analyser or phase-doppler interferometry. The new facility is already attracting considerable interest."

Data from the track sprayer will increase our knowledge of spray deposition and help to improve AGDISP, a computer spray deposition model developed by the US Forest Service. Forest protection scientists recently used the AGDISP model to assist MPI with developing an effective aerial spray programme for the Eucalyptus leaf browser beetle.

For further information:

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Orman Wing laboratories receive international recognition

Lab-works Architects won international recognition for the design of our Orman Wing Laboratory refurbishment, achieving the International Laboratory Buildings award at the S-Lab 2013 International Design Awards. The award recognises architectural and functional elements of laboratory design, including environmental aspects, materials used, energy efficiency and long term sustainability.

The laboratories consist of 1500 square metres of open plan cross-disciplinary

spaces with speciality areas grouped together, innovative storage and safety features, and integration with the campus landscape. Air-conditioning and double glazing also mean the environmental footprint of the building is considerably reduced.

The S-Lab programme, (Safe, Successful, Sustainable Laboratories) is a UK based initiative designed to highlight best practice in laboratory design, operation and management.

Stump to pump

The possibility of being able to power vehicles from sustainably grown biofuels has taken a step closer with the recent investment by Government and industry

into determining the feasibility of transforming wood processing residue into liquid biofuels.

Co-funding by MPI and industry partners Norske Skög and Z Energy will see \$13.5 million invested in the first phase of the 'Stump to Pump' programme to assess the potential for creating biofuels from woody biomass. The funding will be used by the partners over the next 14 months to assess the technical and financial feasibility of the transformation process and determine the commercial viability of establishing a modular test plant.

'Stump to Pump' is the most significant biofuels initiative in New Zealand's history. It aims to create new high-value markets for forestry and wood processing residuals. If this technology can be commercialised, the estimated economic benefit for New Zealand over the next 20-25 years is an annual increase in GDP of up to \$1 billion

Māori forestry hui

Over 200 delegates attended the inaugural Māori Forestry Forum at Rotorua's Waiariki Institute of Technology in August, providing an opportunity for Māori land and forest owners to discuss their aspirations for forestry.

Keynote speaker, Associate Minister for Primary Industries Hon. Jo Goodhew, described Government's business growth agenda and the role of forestry in doubling primary sector exports by 2025. She explained how the economy and the environment can work together, with initiatives such as the permanent forest sink initiative and growing ginseng under pine trees, challenging the forestry sector to increase its share of primary growth partnerships (PGPs).

A strong theme emerging from the forum was the need for iwi to work together to achieve a national Māori forestry strategy and initiatives to increase Māori participation in forestry. The forum was co-hosted by Scion, Waiariki, Federation of Māori Authorities, Te Puni Kokiri and Te Arawa Primary Sector, and supported by Grow Rotorua, Westpac and Taha Beverages.

and the creation of 1,200 direct jobs.

Scion has been sub-contracted to provide research and technology expertise for the Stump to Pump feasibility assessment.

Upcoming events

Kauri dieback symposium

Free public symposium. 9am - 5pm, 30 November

An opportunity for all those interested to learn about kauri dieback, and stimulate dialogue throughout the community around managing the disease. Speakers include politicians, community and iwi representatives and a range of international scientists in forest pathology and ecosystem health, including Professor Giles Hardy. Professor Hardy will present a summary of lessons learned from more than 30 years of dieback management in Australia.

Venue: The University of Auckland, 22 Symonds Street, Auckland

Registration: email biosecurity@aucklandcouncil.govt.nz or phone 0800 NZ KAURI (695 2874)

ABRN Science Symposium: Next Generation Liquid Biofuels and Co-Products. 21 - 22 November

This year's theme is 'Choosing the right biofuel technologies for New Zealand' and will be hosted by the Advanced Biofuels Research Network. The network aims to promote better coordination and collaboration across biofuels research in New Zealand.

Venue: The University of Auckland

Registration: open soon. For further enquiries, email biofuels.symposium@scionresearch.com

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