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Forest Protection Annual Science Report 2015

"Our first Forest Protection Annual Science Report was produced in 2005. Looking back over the previous 10 reports highlights the fact that change is the only constant with major shifts having occurred in our science, our collaborations and the science funding system, and the way we work with our stakeholders."

Forest Protection Annual Science Report

2015 highlights

Northport's post-fumigation exposure period for export logs extended by MPI, providing consistency across all ports in the country.

Our market access research has cleared the way for night loading of sawn timber for export to Australia.

Received MBIE funding to improve pest surveillance and eradication tools for use in urban areas.

Review of global biosecurity undertaken by Dr Eckehard Brockerhoff and colleagues was published in the prestigious journal *'Science'*.

Prometheus fire behaviour model proved to be an effective operational support tool for fire management.

Canopy spray trials have led to adjustments being made to the widely-used AGDISP spray deposition model.

Uptake of phosphite significantly enhanced by using a different adjuvant.

'Healthy trees, healthy future' programme has provided us with a deeper understanding of the *Phytophthora* infection process and resistance interaction.

Contents

Highlights from the past decade

2005

- Major focus on disease caused by *Nectria fuckeliana* in close association with the Nectria Focus Group.
- Refinement of method for molecular identification of *Fusarium circinatum* (pitch canker fungus).
- Quarantine facility running at full capacity in support of pest eradication operations.
- Demonstrated value of bioassays to test efficacy of sprays during urban pest eradication operations.

2006

- Integrated with Ensis, a trans-Tasman collaboration in fire and pest management research.
- Scion contributes to the formation of STIMBR.
- ERMA decision to release buddleia weevil *Cleopus japonicus*.
- Painted apple moth declared eradicated.
- Collaboration with Landcare Research and Plant & Food Research on kauri *Phytophthora*.
- Fire behaviour modelling technologies adopted.

2007

- Began exploring induced resistance to combat pine foliage diseases.
- Long range spray drift trial undertaken in Utah, with Canadian Forest Service, US Forest Service and US army.
- Unsuccessful funding bid for research to support STIMBR.
- Importance of climate change on incidence of wildfire recognised.

2008

- Decision not to continue with Ensis.
- Contributed to eradication of salt marsh mosquito and red imported fire ant.
- Learning about Daño Foliar del Pino in Chile caused by *Phytophthora pinifolia*.
- Participated in IUFRO *Phytophthora* working party.

2009

- Hosted the 2009 IUFRO International Forest Biosecurity Conference.
- Celebrated 60 years of providing forest health research to forestry in New Zealand.
- Growth of international collaborations with many visits to Europe supported by TRANZFOR.
- Major advances in nectria flute canker research.
- Fire programme rated “excellent” by independent review panel.

2010

- Management tools in place for nectria flute canker and market access for logs secured.
- Encouraging results for cleopus weevil on buddleia.
- Co-hosted IUFRO *Phytophthora* working party.
- International collaborations strengthened in fire and biosecurity research.
- Worked closely with rural fire sector to define new research strategy.

2011

- Major shifts in operating environment with CRI Task Force, Statement of Core Purpose and core funding implemented.
- Stronger alignment with NZFOA priorities with a focus on overcoming needle diseases.
- New funding for STIMBR via the Primary Growth Partnership with focus on market access.
- Herbicide research to support industry’s licence to operate under Forest Stewardship Council standards.
- Commenced work to find resistance to red needle cast.
- *Uraba lugens* (gum leaf skeletoniser) biocontrol agent released.

2012

- Celebrating 20th anniversary of rural fire research programme. Programme recognised for excellent research and end-user collaboration.
- New MBIE funding for market access research secured.
- *Phytophthora* risk to log trade mitigated.
- Improved wilding conifer herbicide treatments.
- Aerial spray application expertise applied in kiwifruit orchards as part of Psa research.

2013

- Implementation of forest growers’ levy and new structures to interface growers with science.
- ‘Healthy trees, healthy future’ (HTHF) *Phytophthora* programme funded.
- Five-year needle disease strategy agreed with NZFOA.
- Initiated first kauri dieback symposium.
- New aerial spray technologies developed to eradicate eucalyptus leaf beetle.
- Smartphone ‘App’ developed for fire danger risk information.

2014

- The HTHF and pest management research programmes received industry awards.
- Positive review of Forest Protection research by science and end-user panels.
- Contributed to the development of the National Science Challenges, and ‘Resilience to Nature’s Challenges’ and ‘New Zealand’s Biological Heritage’.
- Ongoing research into biological control for *Uraba lugens* and *Paropsis charybdis*.
- Demonstrated low environmental impact from herbicide use.

Foreword

Our first Forest Protection Annual Science Report was produced in 2005. Looking back over the previous 10 reports highlights the fact that change is the only constant with major shifts having occurred in our science, our collaborations and the science funding system, and the way we work with our stakeholders. At the same time, there are many examples of innovation and end-user uptake of our results that demonstrate the value of our science.

Back in 2005 when we produced our first report, Forest Protection had just become part of the Ensis Joint Venture between Scion and the former Forestry and Forest Products Division of CSIRO. This was seen as an opportunity for increasing collaboration and growing critical mass to deal with similar biosecurity issues on both sides of the Tasman. At that time, our key national stakeholders were the Forest Biosecurity Research Council and the Rural Fire Research Advisory Committee, with STIMBR (Stakeholders in Methyl Bromide Reduction) recently formed; and the Forest Health Research Collaborative and other industry cooperatives were still in existence. Looking back from our vantage at the end of 2015, we can reflect on just how much has changed in the intervening years, as illustrated below.

Fifteen of the 37 Forest Protection staff in 2006 remain at Scion, although another three still contract to the team. While that represents a huge turnover of knowledge, the team has grown in size to 44 staff and now includes the Herbarium. We have also been extremely privileged to recruit many young, talented scientists.

Our major Government funding source in 2006, the Foundation for Research, Science and Technology (FRST), transitioned to the Ministry of Science and Innovation (MSI) and then to the Ministry for Business, Innovation and Employment (MBIE). We have therefore seen constant change in funding structures and increased complexity through to today's landscape that includes National Science Challenges, MBIE Partnerships, MPI Primary Growth Partnerships, Callaghan Innovation funding, MBIE Smart Ideas and Programmes....to name but a few.

The Ministry of Agriculture and Forestry (MAF), our major Government partner in biosecurity, changed to become the Ministry for Primary Industries (MPI).

There has been a complete and very positive change in how we work with the forest industry, especially with the transition to a forest growers' levy and a range of new structures to interface science with forest growers.

A critical innovation in the relationship with forest growers was the development of the NZFOA Forest Biosecurity Research Strategy (2011) and the Science and Innovation Plan 2012, which is currently under revision. Getting clarity on forest growers' priorities, along with the inception of CRI core funding enabled Scion to strongly re-align its research activities to these industry priorities. This step marked a major change in focus and a new urgency in supporting the forest growers' goal of increasing forest productivity and resilience.

Some of our other major milestones include:

- Winning MBIE programmes for Market Access to support STIMBR (2012), the 'Healthy trees, healthy future' *Phytophthora* research programme (2013), and the Pest Eradication programme (2015). Obtaining funding for these programmes highlighted the growing trend and importance of building highly collaborative 'best' teams.
- Several of our staff have been awarded NZFOA and Scion science awards.
- The rural fire research programme celebrated its 20th anniversary in 2012, and was the first Forest Science team to develop an 'app' to help deliver its science.
- An effective herbicide treatment for wilding conifers was developed in collaboration with the Department of Conservation.
- Tools and methods for managing nectria flute canker were successfully implemented.
- Major reviews of our Forest Protection programmes by independent end-user and science panels in 2008 and 2014, gave the team top marks in both categories, which was very reassuring and gratifying.

In February 2016, I will be moving on from General Manager Forest Science to take up a new science role, which I am very excited about.

As this will be my last opportunity to write this foreword I would also like to acknowledge the very many people over the last 11 years who have contributed to its production and, importantly, the science, industry and Government staff who have worked together in partnership to focus the research on the right questions, undertake quality science, and then ensure it is implemented.

As noted in the 2009 International Forest Biosecurity Conference hosted by Scion, we need all three of these parties to work together for an effective research programme.

Dr Brian Richardson
General Manager Forest Science

Foreword

In last year's annual science report, I discussed the positive feedback received from our stakeholders, how close stakeholder engagement has contributed to the progress made with our research, and the formal recognition received by some of our staff. We have continued to perform very well in those areas, however the highlight for me this year was the excellence of our science.

At the very topmost of our science excellence achievements is Ecki Brockerhoff's publication[1] in *Science*. This journal is the second ranked science journal behind *Nature* with an H-index of 851. To publish in *Science* is the dream of scientists both in New Zealand and overseas, with few ever reaching that goal.

The number of publications by Forest Protection staff has steadily increased over the past four years. In 2015, we produced almost 40 publications from our current research along with several more legacy papers from previous work. Pleasingly, our strategy of targeting the best journals has been successful with the science-quality indicators of journal impact factor and H-index having increased every year since 2012. It is important that we deliberately target science quality for a number of reasons. Publication in good journals is important for a scientist's career development. It is also important for the reputation of both Scion and New Zealand that we display our science in the domestic and international arenas. Doing so attracts strong collaborators, generates discussion among peers that leads to new ideas and approaches, and gives our stakeholders confidence that we are doing rigorous science.

Demonstration of science excellence is becoming ever more important now the Ministry of Business, Innovation and Employment (MBIE) has indicated that all new bids for funding in the contestable pool will be evaluated in a two-step process where science quality is considered first, with the remaining bids evaluated on science impact.

We are helping to groom a new crop of scientists who are in various stages of their training. Each summer, Forest Protection hosts about ten students who contribute to our programmes while gaining work experience in a science organisation. In 2015, we also supervised a number of MSc students and 13 PhD students.

This past year we achieved some significant outcomes. For the first time, the fire modelling software Prometheus was used in an operational setting to predict the behaviour of the wildfires in Marlborough. Predictions were run almost at 'real time' and the results used to help fire managers decide whether or not to evacuate people and where best to deploy resources.

Data from our comprehensive quarantine pest trapping network carried out in the MBIE Market Access programme were used to extend the maximum exposure period for logs after fumigation to 21 days in Northland over winter. This extension will reduce methyl bromide use and help with operations at the port. The data were also used to allow night loading of sawn timber onto ships during the burnt pine longhorn flight season. This resulted in a 20% increase in the number of trans-Tasman shipments a company could deliver in a year.

It also looks very likely that our innovative improvements to spray delivery on eucalypts growing in a peri urban area has resulted in the eradication of the eucalyptus leaf beetle from Upper Hutt. That work, carried out three years ago, was the precursor to the successful 'Urban Toolkit for Incursions' bid to MBIE that has resulted in a three-year programme to develop new tools to eradicate pests in urban environments.

Last year, I stated our aims were to make a significant contribution to the 'Resilience to Nature's Challenges' and 'New Zealand's Biological Heritage' National Science Challenges. While it has taken longer than hoped to get to the contracting stage, we are contributing strongly to the development of research programmes in both Challenges and should begin research in early 2016.

I also stated that we would aim to continue to meet stakeholders' needs and allocate core purpose funding judiciously. I believe we have achieved both aims, which would not have been possible without the keen support and feedback of our stakeholders.

For 2016, we have a number of challenges with our Market Access and Rural Fire Research MBIE programmes coming to the end of their funding terms. We are working with industry and Government agencies to secure new investment for these vital areas of research. I am also confident that our science excellence metrics will continue to rise and that we generate strong outcomes for industry from our needle disease programmes.

Finally, I would like to acknowledge Brian Richardson's tremendous contribution to Forest Protection research in his various management roles over the past 11 years. I welcome Alison Stewart as the new General Manager for the Forest Science Group in 2016. Alison brings a wealth of knowledge and experience to the role and I am very much looking forward to working with her.

Lindsay Bulman
Science Leader Forest Protection

[1] Wingfield, M. J., Brockerhoff, E. G., Wingfield, B. D., & Slippers, B. (2015). Planted forest health: The need for a global strategy. *Science*, 349(6250), 832-836.

Entomologist Dr Nicolas Meurisse examining decaying wood for forest insect species.

"The entomology group has had a strong year where the excellent quality work of our team graced the pages of the top scientific journal, *Science*; where we imported a new parasitoid to be evaluated for biocontrol of *Paropsis*; and the market access programme started to deliver results to stakeholders. The team has worked hard to deliver large field and laboratory based experiments throughout New Zealand to collect the robust data required to deliver real impacts for industry, and to underpin our scientific publications".

Dr Steve Pawson
Research Leader, Entomology

Insect pests

Urgent need for a global strategy on forest health

A review of global biosecurity undertaken by Scion's Principal Scientist Dr Eckehard (Ecki) Brockerhoff and colleagues from the University of Pretoria highlights the urgent need for a global biosecurity strategy for planted forests. The review was published recently in the prestigious journal '*Science*'.

"Forests worldwide are continually under threat from introduced insects and pathogens. Without a concerted global effort to control invasive pests, the problem will worsen as international trade increases," explains Ecki. "Planted radiata pine forests have been successful partly because the trees have been separated from their natural pests. This also makes them vulnerable if these pests accidently arrive or the trees encounter new pests for which they have no resistance.

"We have excellent systems in place to prevent the arrival of forest pests and diseases, to respond to incursions, and to manage those that do become established."

"Keeping forests secure relies on quarantine, treatment of imported goods, and monitoring insect traps and trees around ports and other high risk sites. New Zealand has some of the best biosecurity practices in the world but many other countries don't maintain highly effective systems. Once a pest becomes established somewhere, it can be impossible to eradicate and can use the new country as a stepping stone for further invasions."

Ecki says the future of planted forests will be influenced by our ability to respond to damaging pests and the threat of biological invasions. The only way we can

realistically deal with this will be through global collaborations, and the sharing of experience and research.

"Single-country strategies won't be sufficient as the threats to planted and indigenous forests increase worldwide and it is unlikely that poorer countries can afford to maintain the level of biosecurity needed for total exclusion."

Preparing for future invasions will require investment in research and innovation. Scientists in New Zealand and overseas are using a wide variety of techniques combined with knowledge of tree genetics and forest ecosystems to develop non-chemical methods for controlling existing pests and preparing for future threats.

"We have excellent systems in place to prevent the arrival of forest pests and diseases, to respond to incursions, and to manage those that do become established," says Ecki. "But while bodies like the International Union of Forest Research Organisations (IUFRO) help facilitate collaboration, there is no single body or funding structure to support a global strategy for dealing with pests in planted forests.

"It is important for New Zealand to maintain strong international networks to address the biosecurity challenge collectively and, through science partnerships, help countries that may not have the resources or expertise to put biosecurity measures in place."

Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, South Africa

MBIE (core funding)

Wingfield, M. J., Brockerhoff, E. G., Wingfield, B. D., & Slippers, B. (2015). Planted forest health: The need for a global strategy. *Science*, 349, 832-836.

Monitoring the spread of bronze bug in New Zealand

Scion entomologists have been monitoring the spread of the bronze bug, *Thaumastocoris peregrinus*, in New Zealand. The bug, first found in Auckland in 2012 as part of the Ministry for Primary Industries' High Risk Surveillance programme, is a recent introduction from Australia.

Bronze bug is a tiny sap sucking insect that feeds on over 40 species of eucalypts, causing leaf bronzing and stress to the trees. Its feeding damage can lead to premature leaf drop, branch death and in severe cases, tree mortality. Over the past decade, the bug has spread to many parts of the world. It is considered a serious pest of forestry plantations in both South Africa and South America where considerable effort is being put into biological control programmes.

The bug has become so well established in New Zealand that it is not eradicable. A survey conducted by our Forest Protection entomologists in April 2015 showed it has now spread as far south as Hamilton, and we have created a NatureWatch NZ project to encourage citizen scientists to help monitor the distribution of the bug. The most severely affected eucalypt species so far appear to be the popular amenity trees *Eucalyptus nicholii* and *E. viminalis*.

Climate studies have been used to predict further spread of bronze bug throughout the country. Results show it can

potentially establish throughout most of the North Island and in the northern and eastern regions of the South Island, but plantations in the southern South Island are unlikely to be affected. The spread of this pest introduces an element of risk for eucalypt plantation growers in New Zealand, and Scion is closely monitoring its spread and status.

MPI, University of Auckland

Scion Core

Forest health news, (256): Update on the spread of bronze bug in New Zealand.
Forest health news, (233): Distribution and host list for *Thaumastocoris peregrinus*.
Forest health news, (226): A new eucalypt pest has arrived in New Zealand: Bronze bug.
Citizen science project: http://naturewatch.org.nz/projects/spread-of-bronze-bug-in-new-zealand

Extension of post-fumigation exposure period for Northport

Logs exported from New Zealand currently undergo approved phytosanitary treatments, such as fumigation or debarking, to meet the importing country's phytosanitary requirements.

As part of the Scion-led Market Access Research Programme, a four-year programme funded by MBIE and STIMBR to investigate alternative quarantine treatments for export logs, our entomologists have been studying the seasonal distribution and abundance of key forest insects. This is helping us to determine the risk of logs being infested by quarantine pests and whether the 'Area of Low Pest Prevalence' concept can be applied over winter when potential pest pressure is low, and if phytosanitary treatments are still required.

A key aspect of the market access programme is to quantify the forest insect pressure within the landscape and determine which insects will likely pose the greatest quarantine risk at various times. Three species established in New Zealand are being studied: *Hylastes ater*, *Hylurgus ligniperda* and *Arhopalus ferus*.

At the start of the programme three years ago, we established a large scale experimental insect trapping network in forests and ports throughout the country to help us gain a better understanding of the factors that influence insect abundance, and to produce a seasonal national pest pressure map. Since then, the insect population has been monitored daily with data fed into our purpose-designed Bayesian network model to estimate the risk of infestation based on insect flight activity, species dispersal capabilities, temperature and available habitat for beetles, such as dead or freshly cut wood.

Over the past three years we trapped, identified and counted 845,308 individual bark-boring insects from the various locations over 119,506 trap days. These data have been collated into an online data portal and made accessible to our stakeholders to support their pest management decisions.

Based on this work, the Ministry for Primary Industries has extended the maximum post-fumigation exposure period for logs exported during winter (June-August) to 21 days for Northland. Consequently, the maximum post-fumigation exposure period is now applied consistently across all New Zealand ports.

David Finchett, Port Operations Manager at Northport, says "As the owner and operator of a facility where methyl bromide is used, we're pleased to see the progress both Scion and STIMBR are making in this area. Approved changes have been made to reduce the use of methyl bromide with further opportunities identified and being actively pursued. Moving to extending the post fumigation exposure period to 21 days in the winter will contribute toward reducing the amount of methyl bromide used in New Zealand."

Northport

MBIE, Scion Core, STIMBR

Research findings enable night loading of sawn timber

Research findings from the Market Access Research Programme have cleared the way for some New Zealand ports to night load vessels with sawn timber for export to Australia.

Until recently, night loading was prohibited due to the risk of *Arhopalus ferus* (burnt pine longhorn beetle) hitch-hiking on product. The beetles are attracted to the strong lights around loading areas, and during the flight season sawn timber exports to Australia are treated to mitigate risk. Robust data on the night flight activity of *Arhopalus* at ports throughout the country was needed to assess the level of risk involved and determine if the prohibition was justified or not.

The forest insect trapping network established as part of the market access programme (see previous article) provides comprehensive daily trapping of *Arhopalus* at eight forest sites and five ports throughout New Zealand. Data on the distribution and population levels of key forest insect species have been gathered and collated over the past three years enabling the Ministry for Primary Industries to assess the flight activity of *Arhopalus* and make decisions on the future of night loading at individual ports. Based on the results, night loading is now possible during the flight season at all ports except Nelson, Napier and Picton.

Roger Hawthorne from Swire Shipping estimates that this saves a day and a half on the schedule for each voyage during the *Arhopalus* flight season. This time saving allows for a 20% improvement in the number of Trans-Tasman voyages Swire Shipping can deliver the industry over a 12 month period (24 vs 20). In combination with other activities, it contributes toward reducing methyl bromide use.

MBIE, Scion Core, STIMBR

Increasing the efficiency of phytosanitary treatments

Phytosanitary treatments play a vital role in restricting the global movement of forest insects in export logs and timber. Treatments are tested prior to approval and commercial implementation to ensure they provide effective control against any quarantine pests present. However, little is known about the depth they need to penetrate in order to be effective against wood-boring insects. This information will ensure new phytosanitary treatments are effective and wood commodities are not over treated.

We conducted two experimental trials as part of the Market Access Research Programme to determine how deep *Arhopalus ferus* (burnt pine longhorn beetle) and *Prionoplus reticularis* (huhu) larvae can bore into *Pinus radiata* sapwood. Depths were measured over a five month period and under three different temperatures to ascertain how temperature affects the rate of boring and penetration into logs.

Results showed that after five months, each species reached different depths and that the rate of penetration was temperature dependent. At the highest temperature, *A. ferus* and *P. reticularis* larvae bored an average of 27.0 mm and 10.9 mm respectively.

Our new understanding of wood boring rates as a function of time and temperature will help increase the efficacy of phytosanitary treatments. The research team has submitted their findings for publication.

MBIE, Scion Core, STIMBR

Improving New Zealand's border surveillance

New Zealand's forest biosecurity surveillance scheme is currently being revised by scientists in the Better Border Biosecurity collaboration to improve its cost effectiveness and outcomes.

Forest biosecurity surveillance allows for the early detection of new tree diseases or pests that may arrive in the country's exotic forest plantations and other areas. This is crucial to the protection of our forests. Two surveillance schemes operate at present. One involves surveys done in forests (NZFOA funded) and the other is undertaken in high risk sites, funded by the Ministry for Primary Industries. Working together we can make better use of the finite resources that are available for surveillance and achieve the earliest possible detection of new pests and pathogens. This will improve the chances of successful eradication.

Science Leader for Forest Protection Lindsay Bulman says the project team is analysing the current surveillance activities and how each one contributes to the success of the biosecurity system as a whole. New surveillance approaches will be developed based on that framework, enabling protection of the entire national forest estate even though only part of it will be surveyed.

"An incursion of a new damaging pest or pathogen into New Zealand could cost the country millions of dollars in lost production or in trade restrictions," says Lindsay.

"It's already been agreed that the new system will primarily be built on pathway risk rather than pest habitat. We've been working with the Centre of Excellence for Biosecurity Risk Assessment in Australia to create four pest models to predict where the pests might first arrive in New Zealand. All have similar pathways so the risk profile is reasonably consistent for different pests. That way we can design a pest detection surveillance scheme even though we don't know what particular pest will arrive next.

"We have also estimated survey costs for all of the regions in the country, and developed a prototype surveillance model that optimises effort based on risk."

Only six months are left of the two-year project. If successful, the new model could be applicable for use in other sectors such as horticulture and agriculture.

Better Border Biosecurity is an alliance dedicated to protecting New Zealand's plant-based biosecurity, between Scion, Plant & Food Research, AgResearch, Landcare Research, the Bio-Protection Research Centre at Lincoln University, the Ministry for Primary Industries, Department of Conservation and the New Zealand Forest Owners Association.

MPI, CEBRA (Australia), USDA, AgResearch

MPI, Scion Core (B3), NZFOA, CEBRA, SPS Biosecurity Ltd

Integrated management of the eucalyptus tortoise beetle

A Sustainable Farming Fund grant of $500,000 over the next three years has given Scion, the NZ Farm Forestry Association and their co-funding partners the necessary boost to import and test a promising biocontrol agent for the invasive eucalyptus tortoise beetle. A further $600,000 has also been invested by industry, Scion Core funding, and the Specialty Wood Products Partnership to help find a solution to the problem pest.

The eucalyptus tortoise beetle, *Paropsis charybdis*, has been a pest of eucalypts in New Zealand for nearly 100 years. The beetle first arrived from Australia via Lyttleton Harbour in 1916. Since then, it has been causing significant damage to our eucalypt crops, specifically *Eucalyptus nitens* which is grown both for timber and fibre for the pulp and paper industry.

With no natural enemies in New Zealand, beetle populations have been able to increase at an alarming rate, producing two generations each year. Both larvae and adults eat copious amounts of young eucalypt leaves over many months of the year.

We have undertaken a number of spray trials on possible alternative insecticides that will knock back the pest during particularly severe outbreaks without affecting the biocontrol agents.

Scion has been trying to find a suitable biocontrol agent for this pest for decades, but previous efforts, such as the egg parasitoids *Enoggera nassaui* and *Neopolycystus insectifurax*, and a predatory ladybird *Cleobora mellyi*, have struggled to make an impact for various reasons.

Susceptible *Eucalyptus* species continue to be planted in both islands where commercial companies use the broad spectrum insecticide alpha cypermethrin to manage pest outbreaks over the short term. Identifying and subsequently releasing a successful biocontrol agent in forests would provide an alternative to the current spray regimes.

We have undertaken a number of spray trials on possible alternative insecticides that will knock back the pest during particularly severe outbreaks without affecting the biocontrol agents. This has proved challenging with many of the "softer" active ingredients and biopesticides failing to kill either *Paropsis* adults or their eggs when sprayed at commercially viable rates.

"Some potentially good news is that our spray trial with the active ingredient spinetoram has shown the beneficial ladybird *Cleobora mellyi* is largely resistant to the spray, which suggests its use in forests would be more compatible with biocontrol agents," says Programme Leader and entomologist Dr Toni Withers. "However the product did not kill *Paropsis* eggs.

"The long-term focus for the project continues to be on biological control. Ideally we would like to see a biocontrol agent for *Paropsis* established in New Zealand that is able to suppress populations below economically damaging levels."

MPI, NZFOA, Specialty Wood Products Partnership, NZ Farm Forestry Association, Southwood Export Ltd, Oji Fibre Solutions, Earnslaw One, Kaingaroa Timberlands, University of Tasmania

MPI-SSF, Scion Core, NZFOA, Specialty Wood Products Partnership, NZ Farm Forestry Association, Southwood Export Ltd, Oji Fibre Solutions

Fire scientist Grant Pearce monitoring experimental burns on blocks of wilding conifers.

"In 2015 over 2,500 hectares of planted forests burnt, including Wairau Valley forest, the largest single forest fire since 1981. Fire managers called on Scion's Rural Fire Research Team on numerous occasions to help predict the speed, intensity and direction of fires as they burned; essential knowledge for determining what resources to deploy, what roads would be breached, whose homes, livestock, forestry and other assets were at risk, and who to evacuate. Our research into fire behaviour and to develop improved fire risk activity controls and planning processes, is contributing to reducing the risk of wildfires now and into the future."

Dr Richard Parker
Research Leader, Rural Fire Research

Rural fire research

Helping control our wildfire problem

Many introduced species of conifer establish and grow well in New Zealand, spreading their seeds over large areas of the country. In many areas, the spread of 'wilding' conifers has reached weed status.

Relatively little is known about the fire hazard these wildings pose, but with control methods typically involving chemicals, it's likely high due to increased fuel loading and availability. An example of this is the wildfire that swept through Mount Cook Station in 2008, destroying 750 hectares of wildings and grasslands.

This year, the research team, with assistance from the South Canterbury RFA and local fire agencies, began a series of experimental burns on blocks of young wilding lodgepole pines (*Pinus contorta*).

Our Rural Fire Research Team is currently investigating the widely held view that wilding conifers increase the fire hazard in rural areas, and even more so when chemical control measures have been applied. Data collected during the study will be used to update existing fire behaviour models and prediction tools for fire managers, and ascertain how best fire can be used as a potential control tool.

This year, the research team, with assistance from the South Canterbury Rural Fire Authority and local fire agencies, began a series of experimental burns on blocks of young wilding lodgepole pines (*Pinus contorta*) at Pukaki Downs Station in the Mackenzie Basin. The burns will allow scientists to quantify fire behaviour in sprayed and unsprayed stands of wildings, and obtain data on fuel loadings, fire spread rates and smoke behaviour.

"These burns are the most heavily instrumented ever to be conducted in New Zealand," explains fire scientist Grant Pearce. "We're measuring fire spread rates,

in-fire temperatures, fire turbulence and smoke, as well as fuels, weather and atmospheric conditions. In many cases, the equipment and techniques have been newly developed specifically for this project."

The experimental plots were sprayed in January, with burns initially planned for April. These were postponed due to wet weather and the first burns were conducted in October, with the remainder planned for March 2016.

"At this stage we have set up the weather stations to obtain localised meteorological information for the research area, and have collected destructive and non-destructive biomass measurements over time to capture the change in the stand structure and fuel loading," says Grant. "And we've successfully tested the newly developed meteorological gear and fire behaviour sensors during the first set of paired burn experiments."

"We are also working with Scion's Forestry Industry and Informatics Team to determine the accuracy of ground and aerial LiDAR for providing biomass estimates for fuel loading."

University of Canterbury's Geography Department and Engineering Services, South Canterbury RFA, local fire agencies

MBIE, rural fire end-users

www.radionz.co.nz/national/programmes/ourchangingworld/audio/201775547/wilding-pines-go-up-in-flames-in-name-of-science
www.stuff.co.nz/timaru-herald/news/73236299/Wilding-conifers-set-on-fire-for-research

Better planning reduces risk of fire

Scion's Rural Fire Research Team has been working with the Waimea and Marlborough/Kaikoura Rural Fire Authorities to undertake a rigorous three-year review of their current Strategic and Tactical Fire Management Plans (STFMPs) and gain compliance under National Regional Fire Authority legislation.

Fire scientist Grant Pearce says the project is cutting edge, being the first substantive review of triggers, thresholds and activity controls in over 15 years.

"Wildfires can be triggered by a number of activities during the fire risk season, such as roadside mower blades striking a stone, sparks from forestry machinery, or visitors enjoying the numerous cycle and walk ways that crisscross our forests.

"We have increased the scientific rigour of fire management planning by refining and updating activity trigger levels for industries such as forestry, railways, highway maintenance and recreation management. We ran workshops with industry stakeholders to develop a robust scientific basis for activity restrictions and triggers for mitigating fire risk."

Simulated fire growth scenarios were conducted using the fire behaviour model Prometheus to improve fire reduction strategies and Fire Weather Index (FWI) thresholds. Based on the research team's analysis of historic weather and FWI data for each region, it was also decided to divide the existing Extreme Fire Danger category (defined when head fire intensity exceeds 4000 kW/m) into two classes, by introducing a Very Extreme (10,000+ kW/m) category. The concept is already in use in other parts of the world, and recognises that fires with very extreme intensities are impossible to control until fuel, terrain or weather conditions change.

"The tools we have prepared under this project will be very beneficial to all of New Zealand's rural fire authorities as they specifically target the reduction of unwanted ignitions and resulting wildfires," says Grant. "This review will also contribute to the development of a generic national template for all rural fire authorities, to assist in their fire risk planning processes."

Integrated Consultancy Ltd, MKRFA, Waimea RFA

Waimea RFA, MKRFA, rural fire end-users: DOC, NFRA, NZFS, LGNZ, NZFOA, NZ Defence Force

Technical review and report on new and existing activity triggers; workshops with rural fire and forestry managers, and contractors

Fire as a land management tool

There is growing public concern around the use of controlled burns to clear land, in part due to media coverage of a small number of incidents that have had negative outcomes, such as fatalities, excess smoke and the loss of native vegetation.

Fire is a useful land management tool for rural land managers even though it does carry some risk - around 20% of the 3,000 or so wildfires each year are caused by controlled burns escaping, encompassing almost half of the annual area burned. Its uses vary from clearing scrub and agricultural crops, land preparation for pastures or planted forests, promoting the regrowth of grasslands and disposing of vegetative trash.

With the aim of establishing guidelines for the safe and sustainable use of fire as a land management tool, our Rural Fire Research Team recently surveyed New Zealand rural land owners and fire personnel to gain a better understanding of the purposes fire is being used for, the benefits and risks attached to these practices, and land owner perceptions of fire as a useful tool.

The survey showed that land managers and the rural populace have similar rationales for using fire as a tool, but different reasons as to why they don't want to use it, or see it used. Fifty-six per cent of the participants said they use fire as a land management tool, of which 46% were land managers and only 29% of the rural populace. Most burned less than one hectare of land, with the majority conducting fewer burns, and burning less land area now compared to 10 years ago. Participants felt that these trends would continue into the future.

"A preliminary analysis of the results indicate that there are perceived risks involved in using controlled burns as a land management tool that in reality, are not supported by statistics," says fire scientist Veronica Clifford. "The survey has helped us to identify what some of these perceptions are. We can address these issues by providing information and training to rural land users on how to use fire safely and reduce escapes. We can also use our smoke modelling tools to educate fire users on ways to limit detrimental effects of smoke."

Preliminary findings of the survey have been presented at the Forest and Rural Fire Association of New Zealand (FRFANZ) conference.

Federated Farmers, Rural Women NZ, NRFA, Rural Fire Research Advisory Committee

MBIE, rural fire end-users

Hands-on involvement with industry

Interactive workshops held by Scion in August, prior to the Forest and Rural Fire Association of New Zealand conference, gave fire managers the chance to brush up on some skills.

Fire scientist Veronica Clifford ran a refresher course for the Prometheus fire behaviour model, introducing users to new fire scenarios and tools. Fire managers have been using Prometheus for a range of operational and strategic planning and training exercises, enabling more cost effective and targeted fire management practices to be put in place. Due to ongoing demand, Scion will continue to run further training and refresher courses to ensure there are sufficient skilled Prometheus operators around the country.

An Effective Communication workshop was also run by social scientist Lisa Langer to provide guidance on fire prevention publicity and education. Developing appropriate communication strategies for various target audiences helps raise community awareness of the risks associated with wildfires and minimise the number of human-caused fires, as well as increasing community preparedness should such an event occur.

"In a recent study we found that the ability to communicate with at-risk communities is not a simple 'one size fits all' approach," says Lisa. "It requires targeted strategies for different audiences, such as rural or semi-rural fire users,

recreational or cultural fire users, or visitors to the area who are not likely to be using fire but still need to be aware of the risks involved.

"To be truly effective, agencies need to consider a combination of both one-way communication - pamphlets, radio and take-home messaging - and two-way communications, such as face-to-face interactions."

Bushfire CRC, Validatus Research

Workshops sponsored by FRFANZ, NRFA

Pre-FRFANZ conference workshops, posters

Providing real-time information on fire behaviour

Fire managers throughout New Zealand have been making use of our fire behaviour tools to help reduce the risk of wildfires and build more resilient rural communities.

This was demonstrated recently when fire scientist Veronica Clifford used the fire behaviour model Prometheus and the New Zealand Fire Behaviour Toolkit to manage wildfires that raged through Onamalutu in Marlborough during February 2015, destroying 600 hectares of forest and threatening nearby properties. Veronica was part of the National Incident Management team brought in to run firefighting operations. It took 12 helicopters, and 100 fire fighters and crews from Marlborough, Onamalutu and Okaramio Valleys to supress the blaze at a cost of around $1.5 million.

This was the first time Prometheus had been used as an operational support tool to predict fire behaviour and growth, rather than as a strategic planning tool. These predictions formed the basis of operational decisions made by the Marlborough/Kaikoura Rural Fire Authority (MKRFA) around resource deployment and firefighter safety, and to prepare evacuation plans by showing the communities and roads that were under threat.

Principal Rural Fire Officer for the MKRFA, Richard McNamara, says the fire behaviour and growth predictions provided fire crews with accurate, real-time information on a complex fire that involved multiple fuel types on rough terrain. "We used Veronica's predictions to make decisions as to where to concentrate firefighters and aerial support, and when evacuations might be necessary. The wind changing direction was especially concerning."

The day before the Onamalutu fires, Veronica had used Prometheus to run a post-fire review for the South Canterbury Rural Fire Authority on a wildfire that swept through the Mackenzie Basin in February, threatening the township of Twizel. The results were presented at a community meeting to demonstrate how the fire could have spread had firefighting efforts not been undertaken successfully, and the benefits of planting low flammability fuel breaks, such as lucerne, around the town to prevent the spread of any future fires. This is now being implemented.

More recently in December, Prometheus was again used to model the likely spread and risks associated with two further plantation fires in Marlborough's Waikakaho and Wairau Valleys that also threatened properties and damaged large areas of forest.

Prometheus is Canadian software which was adapted for use in New Zealand in 2009. Our fire research team has since trained 46 fire officers in its use.

NZ fire authorities

MBIE, MKRFA, SCRFA, rural fire end-users

Operational fire spread predictions to assist wildfire decision-making; Presentation to Twizel post-fire community meeting; Prometheus refresher training workshop held in conjunction with the annual FRFANZ conference

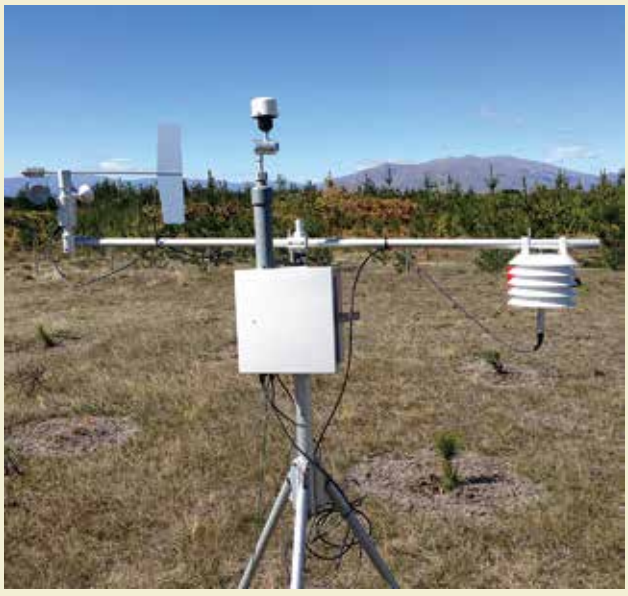
New instrument detects minute particles in the atmosphere

The Rural Fire Research Team recently purchased two 'E-Sampler' instruments capable of detecting minute particles in the air small enough to harm humans.

The 'E-Sampler' machine draws air in through a filter, separating out any particles present and measuring them. The machine is sensitive enough to detect particles and aerosols less than 2.5 microns in diameter (PM2.5). Particles this tiny are capable of breaching the natural defences of the human body and entering the blood stream where they can cause serious harm. Such particles can be present in smoke plumes, dust plumes and other urban industrial sources and are a tracer for rural fire smoke plumes.

Atmospheric scientist and Pest Management Research Leader Dr Tara Strand says "We will be using these instruments to quantify smoke concentrations during our research burns and to help fire authorities with smoke nuisance information during wildfires. We'll also use them in our other atmospheric dispersion research, for example to monitor the size of particles in aerosols that are being used for pest eradication purposes.

"The E-Sampler can also be connected to a satellite so that we can observe the data in 'real-time'."



Dr Nari Williams has been working with a defined set of kauri genotypes to establish screening protocols for kauri dieback.

"Pathogens threaten our native, commercial and urban forests daily. To ensure we are able to effectively diagnose the cause of disease problems and manage unwanted pathogens we need to use a range of new and established technologies while working closely with national and international collaborators."

Dr Rebecca Ganley
Research Leader, Pathology

Forest diseases

Anchoring our relationship with Māori

Kauri and the wider kauri ecosystem are of considerable environmental, cultural, spiritual and economic value to New Zealanders, particularly Māori. Protecting our iconic kauri from kauri dieback disease is a key element of Scion's 'Healthy trees, healthy future' (HTHF) research programme.

From its inception, this programme has recognised the need to work with tangata whenua to achieve the best outcomes for kauri and Māori communities within kauri lands. Through ongoing dialogue, our scientists have sought to develop a deeper understanding of Māori values and contexts, and to establish strong relationships with iwi to ensure we achieve the right balance between science and community engagement.

In 2010, the Kauri Dieback Programme Tangata Whenua Rōpu was established as a conduit between tangata whenua and the Kauri Dieback Programme, one of our collaborators on the HTHF programme.

In July 2015, the Rōpu met with our scientists here at Scion to learn more about the work being undertaken within the HTHF programme and to present our research team with Te Punga, a symbolic waka anchor taonga.

"This was a wonderful opportunity to meet with, and understand the values of the Tangata Whenua Rōpu, and for them to see our connection to plants and to the land."

The waka anchor is beautifully handcrafted from stone originating from a stream in the Firth of Thames. It represents the anchoring of the relationship between Scion and the Kauri Dieback Programme Tangata Whenua Rōpu in striving for a higher level of knowledge in addressing kauri dieback. The muka taura (rope) that is tied to the anchor has been handwoven by all 18 members of the Tangata Whenua Rōpu.

"This was a wonderful opportunity to meet with, and understand the values of the Tangata Whenua Rōpu, and for them to see our connection to plants and to the land," says Programme Leader Dr Nari Williams. "It was a valuable exchange of science and mātauranga.

"The HTHF is an enabling programme in more ways than just science. Some of the templates and technologies we are developing are actually 'enabling' a technology of trust and a linkage between mainstream science with a mātauranga vision for the long term, that sets a foundation for future engagement.

"We are finding new ways of working together, and while the road ahead may still be a bit rocky in places, both parties show a similar vision that will enable the relationship to endure beyond the funding cycles."

Paralleling the forging of this new relationship, has been the development of protocols for screening kauri material to the point where screening can now be up-scaled.

As Nari explains, "During the negotiation phase, our focus was on using robust science and working with a defined set of kauri genotypes to establish screening protocols. This is now completed and we are at the point of involving the wider iwi to screen materials within their rohe over the remaining four years of the programme."

Seedling growth pouches enable scientists to monitor root infection

Phytophthora is a genus of soil or airborne plant pathogens that poses major challenges to global biosecurity, with at least three aerial and 13 soil borne species known to affect *Pinus radiata* globally.

At this stage, little is known about how airborne *Phytophthora* pathogens affect root development. In the 'Healthy trees, healthy future' programme, Scion's pathologists are seeking to gain a better understanding of this host-pathogen interaction by investigating whether the airborne pathogen *Phytophthora pluvialis* could also infect, and cause disease, in *P. radiata* roots. This will help us understand more about the mechanisms of disease resistance and speed up the development of screening programmes against a range of *Phytophthora* pathogens.

The natural root (rhizome) environment is extremely variable and can be influenced by a number of spatial and temporal factors. Sensitive bioassays are required to be able to inoculate the roots of *P. radiata*, and measure their response to infection in an accurately controlled environment. Currently, there are few bioassays that meet these requirements.

A modified seedling pouch growth assay trialled by our research team last year, may be the solution. The assay supports root and disease development of *P. radiata* over time and allows for non-destructive, repeat measurements to be taken. *Pinus radiata* roots were inoculated with both airborne *P. pluvialis* and known soil borne *Phytophthora cinnamoni*, and monitored over a six week period.

The bioassay proved sensitive enough to show the initial impacts of both inoculations on disease development. Results confirm that under experimental conditions, *P. pluvialis* is capable of infecting and causing disease in fine roots between 0 – 0.5 mm in diameter and had some impact on thicker roots. These results are comparable to infection by *P. cinnamomi*.

Landcare Research, Plant & Food Research, Massey University, University of Auckland, Kauri Dieback Programme, DOC, RPBC, AUT, local Māori groups

IFO (France), Murdoch University (Australia), University of British Columbia (Canada), Oregon State University (USA), University of Algarve (Portugal), University of Exeter (UK)

MBIE, Scion Core, FGLT

Defining baselines for red needle cast infection

Scion pathologists are continuing to make inroads into understanding red needle cast, a disease of *Pinus radiata* in New Zealand caused by *Phytophthora pluvialis*.

Understanding how this pathogen causes disease in the field will help us to develop effective control methods and determine which of these provide the greatest level of control. As part of this we need to know if there is a minimum concentration of *P. pluvialis* zoospores required for infection to occur, and whether the concentration of zoospores influences disease severity. This will give us a clearer understanding of how red needle cast symptoms develop in the field, and if the severity of the disease could be reduced by developing control methods that target inoculum production.

Our pathologists use artificial inoculation methods for infecting *Pinus radiata* needles with the pathogen. This helps eliminate the effects of environmental variation, enabling us to investigate many aspects of the disease, including the efficacy of control treatments.

Artificial inoculation methods include detached needle assays, where needles are removed from the plant and inoculated in zoospore suspensions, and on plant assays, where needles are inoculated while attached to the plant. Last year we established the minimum concentration of zoospores required for the reliable infection and symptom development of detached needles. We recently completed a similar study to verify the concentration required to infect attached needles on plants.

Needles from three *Pinus radiata* clones were inoculated with four different zoospore concentrations. Results showed a direct correlation between the concentration of inoculum and disease severity. Needles can be infected at very low zoospore concentrations, but there is an inoculum threshold between 200 and 2,000 zoospores per ml that influences lesion length and the number of lesions. This suggests that reducing inoculum levels in the field could significantly reduce disease levels, and that control methods that effect the production or survival of zoospores could be very effective.

Further work is required to determine how inoculum concentration and environmental conditions effect disease expression in forests under natural conditions.

Scion Core, FGLT

Improving New Zealand's readiness for a biosecurity incursion

Scion and our Better Border Biosecurity (B3) partners are constantly seeking to improve New Zealand's biosecurity by ensuring we have the necessary tools to respond to potential incursions. *Phytophthora* pathogens in particular, pose a serious biosecurity risk. They are some of the most destructive plant pathogens worldwide with many species having a wide range of hosts. The recent emergence of epidemics caused by airborne *Phytophthora* species, for example *P. pluvialis* in New Zealand, demonstrate the difficulties in managing these pathogens once they are introduced, particularly in countries where endemic plant species have no defence against them.

Phosphite is one of the only known cost-effective chemical controls of *Phytophthora* worldwide. It has been shown to control *Phytophthora* related diseases for many years, often after a single application. Phosphite acts by suppressing the pathogen's activity while simultaneously inducing a strong and rapid response to infection in challenged plants. Foliar application has also been shown to directly reduce the spread of *Phytophthora* pathogens making it a valuable containment tool in the advent of new incursions.

At effective application rates phosphite has low toxicity to other plants or mammals, and is easily applied to the infected tree via stem injections or foliar sprays with minimal off-target or physiological effects. Prior to this study, little was known about the physiological impacts phosphite has on our native plant and forestry species despite its widespread use on horticultural crops.

Since 2012, Scion has been studying the sensitivity of our two most economically important exotic forestry species, *Pinus radiata* and *Pseudotsuga menziessii* plus 13 native keystone species, to phytotoxicity caused by phosphite applied at concentrations required to control disease. The native species were kauri, pikopiko, tawa, cabbage tree, kahikatea, rimu, akeake, kānuka, mānuka, pōhutukawa, red beech, totara and miro.

Our findings suggest minor phytotoxic effects result from the foliar application of phosphite across diverse species regardless of concentration, supporting its use as a management tool for *Phytophthora*-related diseases in plantations and natural ecosystems. This study is now complete and will be published in the journal *Physiological Plantarum*. The research was also presented to the Australasian Plant Pathology international conference in September 2015.

Scion Core (B3)

Advancing our work through international collaboration

During the early stages of the Scion-led 'Healthy trees, healthy future' (HTHF) programme, our strategy included sending scientists to international conferences to introduce the project model to a broad international audience. Critical feedback was received from researchers working in host-pathogen systems biology, with our metabolomics multi-platform approach confirmed as the leading one internationally.

These early visits seeded the development of national and international collaborations with other research parties such as England's Exeter University, the University of British Columbia in Canada, and Canterbury and Otago Universities.

International collaborations are a driving force in progressing our understanding of New Zealand's key *Phytophthora* pathogens.

The HTHF programme has aligned our *Phytophthora* genome work with the International Phytophthora Genome Consortium. As a result, collaborators Dr Nik Grunwald (United States Department of Agriculture and Oregon State University), Professor Richard Hamelin (University of British Columbia) and Professor Brett Tyler (Oregon State University) were invited to attend the Phytophthora Computational Biology session at the Queenstown Molecular Biology meeting in August 2015.

Through these collaborations, we have been able to add 12 *Phytophthora* genomes to the consortium server for further annotation using the consortia's standardised protocol. This has greatly advanced our work by enabling a direct comparison to the genomes of 26 other *Phytophthora* species already compiled by the consortium.

It has also furthered our ongoing collaboration with Associate Professor David Studholme and Professor Murray Grant at the University of Exeter in sequencing *Phytophthora* genomes, particularly *P. pluvialis*, *P. kernoviae* and *P. agathidicida*.

USDA; Oregon State University (USA), University of British Columbia (Canada), University of Exeter (England), Murdoch University (Australia)

Landcare Research, Plant & Food Research, the Kauri Dieback Tangata Whenua Rōpu, Massey University, AUT, University of Auckland

MBIE, Scion Core, FGLT, RPBC, MPI Kauri Dieback Programme

www.healthytrees.co.nz

Supporting our students; building a healthy future

Our 'Healthy trees, healthy future' (HTHF) students are helping to build the future of New Zealand's response to forest diseases.

Doctoral student **Simren Brar** joined us in October 2014 from Canada. Simren is looking into the molecular host-pathogen interactions of airborne *Phytophthora* species in *Pinus radiata* forests. With the support of her supervisors, Dr Rosie Bradshaw (Massey) and Drs Rebecca McDougal and Nari Williams, and funding through the HTHF and Better Border Biosecurity programmes, Simren is at present seeking to understand the diversity of *P. pluvialis* as part of her research project.

Mireia Gómez Gallego began her PhD in our HTHF and Needle Disease Strategy research programmes in May 2015. Mireia is investigating the prevalence and physiological impacts of *P. pluvialis* and *P. kernoviae* in New Zealand and Oregon forests. This includes contrasting *P. pluvialis* infection in *Pseudotsuga menziesii* and *Pinus radiata*.

Mireia is enrolled through the Auckland University of Technology with academic supervision from Dr Sebastian Leuzinger. Mireia's project is based in Rotorua, where she is being supervised by Drs Nari Williams, Martin Bader and Peter Scott.

Echo Herewini is completing her master's degree on kauri dieback and establishing protocols to screen for genetic resistance in kauri. Echo's project is funded by the BioProtection Research Centre with further funding and supervisory support from Scion through the HTHF programme. She is supervised jointly by Drs Rosie Bradshaw and Terry Stewart (Massey University), Drs Peter Scott and Nari Williams, and Dr Phil Wilcox (Otago University).

USDA; Oregon State University (USA), University of British Columbia (Canada), University of Exeter (England), Murdoch University (Australia)

Landcare Research, Plant & Food Research, local Māori groups, Massey University, AUT, University of Auckland

MBIE, Scion Core, FGLT, RPBC, MPI Kauri Dieback Programme

Progress in needle disease research 2013 - 2018

Research into needle disease is considered a high priority by forest growers and the Ministry for Primary Industries.

In 2013, a five-year strategy was developed to reduce impact of needle diseases on New Zealand forests. The Scion-led programme brings certainty and direction in needle disease research by building a platform of domestic and international capability, knowledge and tools to identify and respond quickly and efficiently to the complex issues of disease management in trees.

Theme	2013	2014	2015
Predict disease	Monitoring sites established in central North Island and East Cape	*P. pluvialis* and *P. kernoviae* have long infection periods, March to October	Monitoring sites to predict disease from weather variables established
		Positive relationship between *P. pluvialis* zoospore concentration and disease established	
			Minimum zoospore concentration needed for infection determined
		Inoculum presence varies greatly depending on location and time of the year	
Host resilience		Differences in *P. radiata* susceptibility shown	Clonal susceptibility rankings determined *in vitro*
			Links between host genotypic variation, pathogen epidemiology and inoculum potential identified
	$2.5 million 'Healthy trees, healthy future' MBIE progamme started	Genomes assembled for 10 *Phytophthora* species	Joined International Phytophthora Genome Consortium
			Phytophthora genomes used to initiate analysis of *P. kernoviae* isolates from NZ, Chile and UK
	International and domestic collaborations developed		Host physiology hypothesis model for needle disease developed
Controlling disease		Phosphite active against *P. pluvialis* and *P. kernoviae* in field and lab studies	
		Effects of stem injected phosphite lasted at least 12 months	Phosphite uptake significantly increased by using new adjuvant
			Aerial spray trial planned and established
		Copper shown to control *P. pluvialis* in lab	Cost benefit analysis of aerial spraying to control RNC proves feasible
		Spray applied to control dothistroma needle blight reduced to 3 l/ha with no loss of efficacy	Phosphite has minimal negative impacts on non-target plant species

Pest management technician Carolina Gous studying buddleia in an establishing plantation forest.

"We're constantly seeking to improve New Zealand's biosecurity. This means having a well prepared toolkit to tackle any new plant pests and pathogens arriving into the country, and to manage those already established, in an environmentally safe way. We're working closely with end-users to ensure we deliver a suite of pest management tools that safeguard our vital primary industries as well as our communities and the environment in which we live."

Dr Tara Strand
Research Leader, Pest Management

Pest management

Developing a toolkit for the urban battlefield

As New Zealand's valuable trade and tourism industry expands, so too does the risk of new plant pests arriving into the country. Protecting our vital primary industries from damaging plant insects and pathogens is the aim of a new MBIE-funded programme, 'Protecting New Zealand's primary sector from plant pests: a toolkit for the urban battlefield'. Led by Scion, this inter-agency programme responds to the urgent need to improve pest surveillance and eradication tools for use in urban areas where incursions are most likely to occur due to their location near the country's sea and air ports.

"Our aim is to find lower impact alternatives to large-scale aerial spraying of pesticides so that in the future, it only needs to be used as a last resort. We will also develop more efficient methods to manage pests that are already established."

The Government is investing $3.75 million in the 'urban battlefield' programme, with further investment by Scion and our partners amounting to a total of $4.5 million over three years. Research and Programme Leader Dr Tara Strand says the research will provide an integrated package of tools to address the technical, cultural and social issues confronting agencies involved in eradication programmes.

"Our aim is to find lower impact alternatives to large-scale aerial spraying of pesticides so that in the future, it only needs to be used as a last resort. We will also develop more efficient methods to manage pests that are already established. A spill-over benefit will be improved protection of our conservation estate."

The programme involves three areas of research - active surveillance, low-impact eradication methods, and understanding communities. Improved surveillance means pests will likely be detected earlier, increasing the likelihood of their successful eradication and preventing the long-term control costs associated with

high impact pests that become established. The use of low impact eradication methods also safeguards New Zealand against trade sanctions associated with pesticide use, protecting our competitiveness in the global market. Socially acceptable protocols for new and existing technologies will help agencies with risk and communication strategies before and during incursion.

Improvements to the country's biosecurity as a result of this programme are worth an estimated $2.5 billion (net) to the sector. The programme will be supported by a steering committee made up of representatives from Government, regional councils, primary producers and Māori. End-user involvement will ensure delivery of fit-for-purpose tools and methods. The research programme is linked to both Better Border Biosecurity (B3) and the Biological Heritage National Science Challenge.

Will Allen and Associates, Aeronavics, Auckland City Council, Eco Research Associates, Hammond Resource Management, HeliResources, Landcare Research, Lincoln University, PPCNZ, Canterbury University, CNRS (France), INRA (France), USFS (USA), and Forestry Commission (UK)

MBIE, Scion Core (B3); co-funded by MPI, DOC, NZFOA, Councils, KVH, Pipfruit NZ. In-kind funding from Aeronavics, HeliResources

Complex spray drift trial beneficial for wider application

In April, our Pest Management Team and scientists from the University of South Carolina and the US Forest Service conducted a field trial to study the effects of turbulence on aerial spray deposition at the canopy top.

Turbulence created by the roughness of a forest canopy is an important factor in calculating aerial spray deposition. It is possible the AGDISP spray deposition model, used worldwide to compute aerial spray drift, is overestimating drift in some circumstances due to an underestimation of spray deposition at the canopy top.

"Measuring spray drift over a forest canopy is highly complex and challenging" says Research Leader Dr Tara Strand. "We used the University of South Carolina's state-of-the-art elastic backscatter LiDAR instrument to measure the height and density of the drifting spray cloud. This trial was the first application of combining LiDAR data with standard deposition sampling within and above rough elements like a forest canopy."

Tara says the trial was very demanding and involved setting up a 10 m sampling tower, eight smaller towers equipped with sampling devices, plus another 10 m tower equipped with five wind sensors and eight temperature sensors to measure changes every second or less.

Preliminary results indicate that the AGDISP model does overestimate spray drift by potentially up to a factor of 10 under some circumstances. The amount of drift is small relative to deposition, so this seemingly large number was not unexpected. Improvements to AGDISP will be made after further analysis and confirmation of these early numbers. These results will benefit control and eradication programmes that have to maintain a high environmental standard of reduced drift while placing enough pesticide in the canopy to meet application objectives. Along with the obvious benefits of reducing pesticide treatment costs, the collated dataset has the added benefit of enabling better prediction of pathogen, pest and wilding spread.

University of South Carolina, USFS (USA), PPCNZ, Lincoln Agritech. With assistance from HeliResources

MBIE (through Lincoln Agritech), Scion Core (B3), USFS (USA)

Atmospheric LiDAR (YouTube video) bit.ly/1P3bI9n

Minimising the environmental impact of herbicides in planted forests

Since 2012, Scion's Pest Management Team has been studying the long-term environmental effects of a number of key herbicides used in New Zealand planted forests. This includes identifying acceptable herbicides, reducing spray volumes and investigating the fate of herbicides in different forest environments.

"Forestry companies that are Forest Stewardship Council (FSC) certified need to demonstrate that they are using herbicides in an environmentally acceptable manner," says pest management scientist, Dr Carol Rolando. "Continued use of herbicides depends in part on whether they break down in forest soils or leach into waterways. The FSC-certified forest industry needs robust data that shows what impacts key herbicides have on the environment."

This information can be used to make independent assessments of the environmental risks associated with operational management programmes using herbicides. If the risks to water quality are shown to be negligible, the evidence can be used to support grant applications for continued herbicide use.

This was the approach used for terbuthylazine and hexazinone, which were prohibited for use on certified forest land between 2007 and 2015. Terbuthylazine and hexazinone are the most effective and widely used herbicides in New Zealand planted forests. Our research has played a key role in supporting their continued use under derogation on FSC-certified land between 2012 and 2015, and likely supported their removal from the list of FSC-prohibited herbicides in 2015.

"We used this knowledge to help the Auckland Council establish streamside management zones in the Hunua Ranges, which allowed terbuthylazine and hexazinone to be applied to establishing forests that adjoin sensitive water catchments in the area," says Carol.

Scion's research on minimising the environmental impacts of forest herbicides has supported the forest industry's licence to operate as FSC certified, and maintain access to lucrative global wood and wood products markets.

USFS (USA)

Scion Core, AgResearch, FSC Cluster Group, FGLT

Minimising the environmental impact of forest weed management in New Zealand. www.scionresearch.com/pest-management

Weed Management in New Zealand Planted Forests (YouTube video) bit.ly/1PBzeWs

New Zealand Forestry Bulletin, Spring 2015; Key Herbicides Cleared, p7.

New Zealand Tree Grower, August 2015; Clean and green – controlling weeds in planted forests, p30.

Investigating chemical control options for red needle cast

Our pest management scientists are currently investigating two fungicides as cost-effective and FSC-compliant chemical controls to suppress red needle cast in *Pinus radiata* forests. The disease, caused by *Phytophthora pluvialis*, can cause up to 16% annual growth loss in mature plantations.

Phosphite is known to be effective against *Phytophthora* diseases (see *Improving New Zealand's readiness for a biosecurity incursion*, page 21). It acts directly on the pathogen as well as stimulating the host's defence response to the disease, with the effects lasting for over a year depending on the host. The effectiveness of phosphite is influenced by how much of the chemical is taken up by the host. Uptake can be enhanced with the use of adjuvants to improve spray deposition, penetration, droplet spread and retention.

Pesticide application and vegetation management specialist Stefan Gous used Scion's track sprayer to test the effectiveness of two phosphite containing fungicides under controlled conditions.

"Initial tests on Agri-Fos®600 showed variable success but with some needle scorch," says Stefan. "Further tests showed that the chemicals were unstable in one another's presence indicating that the adjuvant was being degraded by Agri-Fos®600.

"However Foschek™ looks promising. It's formulated differently and gave the best results even without the use of an adjuvant. This is a positive outcome for both the cost and benefits of spraying with phosphite."

Stefan and the team also trialled copper in the form of cuprous oxide as a suitable fungicide. As Stefan explains "Cuprous oxide has been used for years to treat dothistroma needle blight. It could also be effective against red needle cast, and if so, application would treat both diseases at once. Currently, the effectiveness and longevity of this treatment as a control for red needle cast is unknown and warrants further investigation."

These results have made a positive contribution towards the development of an operational control strategy for red needle cast in existing *Pinus radiata* forests. An aerial field trial is planned for early 2016 to validate these findings.

PPCNZ

Scion Core, FGLT

Achievements and accolades

Awards and honours

Dr Tara Strand was awarded a Visiting Scholar Fund from the University of South Carolina to visit Dr April Hiscox and complete publications initiated during April's sabbatical to Scion in March.

Dr Rebecca McDougal received a travel award from the Oomycete Molecular Genetics Network (supported by USDA) to travel to the OMGN Bioinformatics Training Workshop in Blacksburg, USA in June.

Jessica Kerr won a QEII Technicians' Study Award to study forest insects in North America.

New Zealand Forest Owners Association Awards (NZFOA)

Dr Eckehard Brockerhoff was awarded Science of International Standing at the Forest Growers Levy Trust Conference in Nelson for helping to raise international awareness of biosecurity issues to protect New Zealand from potentially devastating incursions.

Scion Awards

Fire scientist **Veronica Clifford** won the Customer Engagement Award for her fire behaviour forecasting work.

Dr Martin Bader received the 'Established Researchers' Fund' worth $30,000 to investigate the link between tree physiology and wood mechanical properties.

Student Awards

Simren Brar received the inaugural Ross Beever Memorial Mycological Award to further her work in analysing the diversity of *Phytophthora pluvialis*.

Daisuke Seto from the University of Canterbury was awarded Best Student Presentation at the Meteorological Society of New Zealand Conference in November. The presentation 'Atmospheric mixing processes during wildfires: Implication for extreme fire behaviour' was jointly authored by PhD advisor Dr Tara Strand.

Kevin Chase (University of Canterbury, School of Biological Sciences) was awarded Best Presentation Overall at the Annual Biology Conference of the SBS for his talk 'Allee effects determine whether invasive species establish'.

Masters student **Echo Herewini** received Best Student Presentation at the Australasian Plant Pathology Conference in Perth for her presentation 'Foliar inoculation of *Agathis australis* infected with the soil borne pathogen *Phytophthora agathidicida*'.

Doctoral student **Gonzalo Avila** (University of Auckland) won third place in the 'Nikon Small World in Motion' for his video of *Cotesia urabae* emerging from a gum leaf skeletoniser larva.

Grants

Drs Rebecca McDougal and **Emily Telfer** (Forest Genetics) won a 'Freedom for You' grant from Ubiquitome Ltd to purchase a portable qPCR device worth $25,000 for in-field disease diagnosis.

Professional positions

Toni Withers continued in her role as Honorary Treasurer for NZ Plant Protection Society.

Publications

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Glossary

AUT	Auckland University of Technology
B3	Better Border Biosecurity Alliance
CEBRA	Centre of Excellence for Biosecurity Risk Analysis (Australia)
CNRS	National Centre for Scientific Research (France)
CRC	Bushfire Cooperative Research Centre
CRI	Crown Research Institute
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DOC	Department of Conversation
FABI	Forestry and Agricultural Biotechnology Institute, University of Pretoria (South Africa)
FGLT	Forest Growers Levy Trust
FRFANZ	Forest and Rural Fire Association of New Zealand
FRST	Foundation for Research, Science and Technology
FSC	Forest Stewardship Council
FWSYS	Fire Weather System
HTHF	'Healthy trees, healthy future' research programme
KVH	Kiwifruit Vine Health
INRA	French National Institute for Agricultural Research (France)
IUFRO	International Union of Forest Research Organisations
LiDAR	Light Detection and Ranging
LGNZ	Local Government New Zealand
MAF	Ministry of Agriculture and Forestry
MBIE	Ministry of Business, Innovation and Employment
MKRFA	Marlborough/Kaikoura Rural Fire Authority
MPI	Ministry for Primary Industries
MSI	Ministry of Science and Innovation
NIWA	National Institute of Water and Atmospheric Research
NRFA	National Rural Fire Authority
NZFOA	New Zealand Forest Owners Association
NZFS	New Zealand Fire Service
PGP	Primary Growth Partnership
PPCNZ	Plant Protection Chemistry New Zealand
RNC	Red needle cast
RFA	Rural Fire Authority
RPBC	Radiata Pine Breeding Company
Scion Core	Crown Research Institute Core Purpose Funding
SCRFA	South Canterbury Rural Fire Authority
SFF	Sustainable Farming Fund (MPI funding)
SPS Biosecurity	SPS Biosecurity Ltd
STFMP	Strategic Tactical Fire Management Plans
STIMBR	Stakeholders in Methyl Bromide Reduction
UBC	University of British Columbia (Canada)
USDA	United States Department of Agriculture
USFS	United States Forest Service

Collaborators Investment Website Associated outputs

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