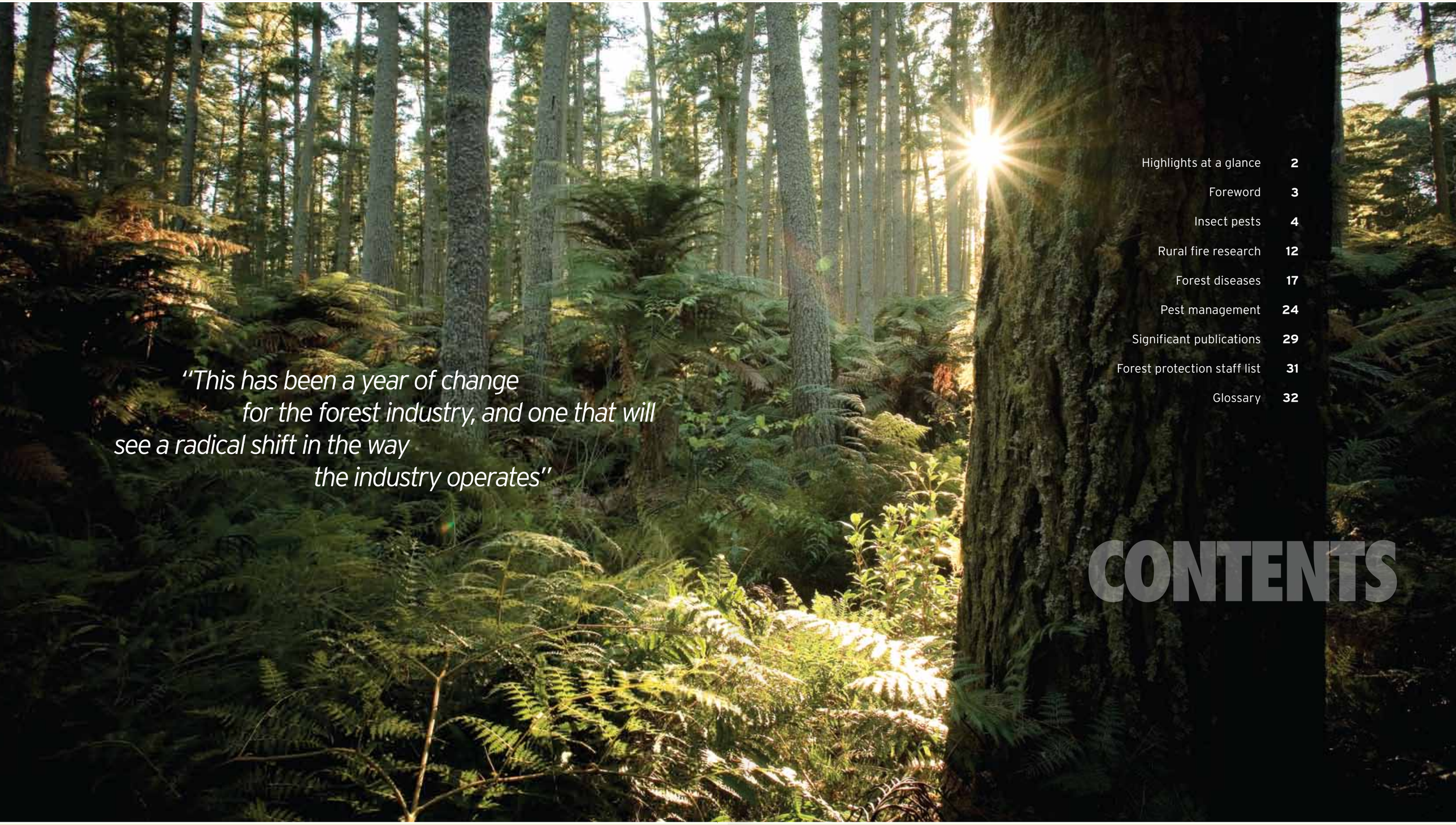
SCION
forests · products · innovation

FOREST PROTECTION ANNUAL SCIENCE REPORT 2013



CONTENTS

HIGHLIGHTS AT A GLANCE

A national pest trapping network will help determine a fumigant-free period for export forest products during winter.

The new Fire Weather System provides a one-stop-shop for fire managers.

A DNA barcode library for Myrtaceae species will aid rapid identification of host species in the event of a myrtle rust incursion.

Scion has received funding to lead a collaborative research programme into *Phytophthora* diseases.

Breeding for red needle cast resistance in radiata pine will develop germplasm with increased tolerance to the disease for high risk areas.

Two new aerial spray methods will target key host trees for eradication programmes in sensitive locations.

FOREWORD

This has been a year of change for the forest industry, and one that will see a radical shift in the way the industry operates. The implementation of the forest growers' levy, in particular, will have a significant impact on all areas of forest growing research. The formation of a new structure to interface forest growers with science will bring research activities together under one umbrella, and the appointment of Russell Dale as industry research and development manager, will create a single point of contact for industry and science alike. The streamlining of research will encourage greater collaboration across large, diverse teams that will benefit the entire industry.

Our focus at Scion, too, is one of collaboration and this year the Forest Protection Team has demonstrated some tangible examples of this.

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

Winning this bid has truly been a team effort. Led by Dr Nari Williams, our Forest Protection, Forest Genetics and Biotransformation Teams worked closely with industry to ensure the science we provide will address industry needs. This highly collaborative *Phytophthora* project brings together multi-disciplinary teams and exciting science, nationally and internationally, to identify hosts with a broad resilience to a number of *Phytophthora* species, and to accelerate breeding programmes. Our research will focus on host species that are of significant economic and cultural value to New Zealand - radiata pine, apple and kauri. (see page 18)

The support from our industry colleagues also provides the level of co-funding we need to enable us to deliver greater impact to forest growers by targeting diseases such as red needle cast. (see page 22)

As part of this project, we welcome the opportunity to work alongside iwi, DOC and the Kauri Dieback Joint Agency Response on the development of screening programmes and propagation channels to stem the spread of kauri dieback disease. The recent Kauri Dieback Symposium, an initiative of Scion pathologist Dr Peter Scott, attracted over 120 land managers, scientists and members of the public from around the country who are working to protect New Zealand's iconic kauri from this damaging disease. (see page 20)

We continue to work with Plant and Food Research to perfect the breeding protocols of common wood and bark eating insects, as part of the methyl bromide reduction project. This provides data on pest emergence, critical to defining a fumigation-free period for log exports, while providing insects for fumigation testing. (see page 10)

Another example of this collaborative approach has been the development of new aerial spray application techniques for the eradication of pests in sensitive areas. Forest Protection scientists teamed up with HeliResources and Hammond Resource Management to develop the spot gun and spot-boom methods which have been utilised by the Ministry for Primary Industries in eradicating the *Eucalyptus* leaf beetle. (see page 26)

Furthermore, the development of a smartphone 'app' that makes up-to-date, localised information on the fire danger risk publically available, has been the result of our fire researchers working in conjunction with the University of Canterbury and Tait Communications. The *Today's Fire Danger* app is now being trialled by fire managers and fire fighters around the country. (see page 15)

Moving into 2014, we expect to be heavily involved in the development and implementation of New Zealand's National Science Challenges. Working with the Natural Hazards Research Platform our fire team contributed to the 'Resilience to Nature's Challenges' proposal that was submitted in December. Should Government accept our bid, it will align our fire research programme with other hazards research, such as earthquake and emergency response, bringing with it new skills and new collaborations. We expect that the Biological Heritage Challenge will also facilitate greater collaboration for our Forest Protection Team.

We look forward to meeting these exciting challenges, making new discoveries and forging new partnerships in the year ahead.

Dr Brian Richardson
General Manager Forest Science

INSECT PESTS

Adult and larval stages of the golden-haired bark beetle, *Hylurgus ligniperda*.

A YEAR OF REJUVENATION FOR OUR ENTOMOLOGY TEAM

Scion's Entomology Team has enjoyed a year of many successes from the identification of potentially threatening pests to New Zealand, to the welcome infusion of new expertise into the team and the strengthening of international collaborations. Each member of the team brings to the mix their own specialised area of expertise. The addition of two new scientists, Drs Nicolas Meurisse and Cecilia Romo, and technician Andrew Pugh, significantly strengthens and diversifies our skills.

Protecting our markets

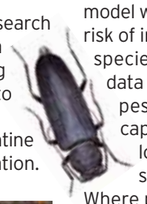
We focus on four key areas of research: pre-border entomology, post-border entomology, market access entomology, and collections and taxonomy.

Prevention being better than cure is the premise behind our pre-border research. Adopting a multi-lure approach to pest trapping and addressing pathways of risk for pests entering the country are collaborative projects aimed at stemming the flow of invasive forest pests into New Zealand and worldwide.

Despite these efforts, some invasive pests do become established in New Zealand's forests. Our team works closely with the Ministry for Primary Industries, universities and other research institutes to identify and evaluate the level of threat new and existing invasive species pose to the country's forest or amenity trees. One such example is the bronze bug, *Thaumastocoris peregrinus*, which is new to New Zealand and as yet confined to the Auckland region. If uncontained, however, the bug could threaten the expansion of eucalypt plantations and decimate thousands of amenity trees across the country.

A major focus for the team at present is protecting New Zealand's market access. Entomology Research Leader Dr Stephen Pawson is leading a collaborative MBIE funded programme to investigate alternative quarantine treatments for our export logs.

"There are three main areas of research in this programme – establishing a fumigant-free period, developing alternative chemical fumigants to replace methyl bromide, and investigating non-chemical quarantine treatments such as heat and radiation.



"To ascertain the duration of a fumigant-free period during winter, we have established a national pest trapping network in forests and ports to monitor pest populations around the country, 24 hours a day, seven days a week. Data from these will be fed into a Bayesian model we are developing to estimate the risk of infestation by phytosanitary pest species. The model will be based on data we have collected for seasonal pest activity, pest dispersal capabilities, temperature, and the location of available food sources such as dead or freshly cut wood. Where possible, the team leverages off previous work done at Scion."

Helping to secure our borders

Our Entomology Team hopes to contribute strongly to risk analyses and development of contingency plans over the next few years as MPI and the forest industry gear up for the Government Industry Agreements (GIA). The GIA initiative began in 2009 to help the country prepare for, and respond to biosecurity risks. It creates the opportunity for industry to identify

biosecurity risks of greatest concern and jointly invest with Government to better manage those risks through such things as risk assessment and eradiation techniques.

Across the boundaries

The protection of New Zealand's international trade in wood and wood products is vital to our economy and central to the work our Entomology Team does. Establishing strong international links between countries helps trading partners protect their borders against the introduction of new plant pests. Some of our successes this year include:

- Dr Stephen Pawson attended the annual International Forest Quarantine Research Group (IFQRG) meeting in China. This group advises the International Plant Protection Convention on scientific matters relating to international standards for trading in plant commodities to avoid spreading unwanted pest species. It is hoped Scion will host a meeting within the next few years.

  Stephen is currently president of the New Zealand Entomological Society and on the board of the Australasian Bayesian Network Modelling Society.

  He is also working with the United States Department of Agriculture Forest Service on using LiDAR to quantify biodiversity in forests.

- Principal Scientist Dr Brockerhoff is recognised as an international leader in forest entomology. This year he:
  - was elected as International Union of Forest Research Organisations (IUFRO) Division 7 (Forest Health) coordinator from 2014 – 19, which includes a seat on the Board of IUFRO
  - is currently the coordinator of the IUFRO Task Force on Biodiversity and Ecosystem Services
  - attended the IFQRG meeting in China with Stephen Pawson
  - was a keynote speaker at the International Congress on Planted Forest in France
  - participated in the "Globalisation of the Live Plant Trade" workshop in the USA aimed at developing strategies to reduce the risk of pest invasion
  - hosted visiting scientists from France, Italy and the USA.

- Dr Toni Withers is currently Treasurer of the New Zealand Plant Protection Society and helped organise their annual conference in Napier.

PEST INFESTATION AT WOOD PROCESSING SITES: HOW TO REDUCE THE RISK

To ensure New Zealand's valuable international trade in wood products is protected, our forest products must be pest free when they arrive at importing countries. Managing the risk of hitch-hiking insect pests at wood processing and storage sites is an important component to Scion's research to develop sustainable integrated quarantine requirements for forest exports.

We have recently published a summary of research, co-funded by STIMBR and MPI-PGP, explaining how industry operators can minimise insect infestations at processing sites and ports by such things as improving site hygiene, modifying lighting and using temporary insect-proof enclosures.

This will soon be available to download at *www.scionresearch.com/general/publications*

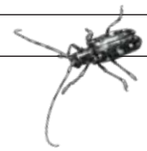
A MULTI-LURE APPROACH TO MONITORING FOREST PESTS

Surveillance trapping using species-specific attractants is a powerful and cost effective method for detecting invasive forest species.

Scion has been working with other research partners to adapt this approach and monitor several species simultaneously by combining multiple lures in a single trap. The multi-lure approach could potentially be implemented with existing surveillance activities for gypsy moth, a feared defoliator of numerous tree species often intercepted at New Zealand borders and for which a nationwide network of traps is already in place.

Results to date indicate that additional lures may reduce the attraction for some species but that the method is compatible for numerous other target species. Our initial work has been published in the Journal of Chemical Ecology and operational research funding from MPI has been secured to further develop this concept in collaboration with Plant and Food Research.

Research partners: Plant and Food Research via B3, FFPRI (Japan), INRA (France), Technical University of Lisbon (Portugal), University of Padua (Italy), USDA
Investment: Scion Core, MPI



ANALYSING INTERNATIONAL WOOD PACKAGING STANDARDS

International Standards for Phytosanitary Measures (ISPM) are multilateral agreements that specify treatment standards and measures to prevent the spread of invasive pests between countries.

The first cost-benefit analysis has recently now been completed on ISPM 15, the international standard for wood packaging materials. Wood packaging such as pallets, case wood and dunnage, is often made from low quality wood and has many destinations. The ISPM 15 requires such packaging is either heat treated or fumigated to prevent the spread of wood borers and bark beetles.

The ISPM 15 was analysed for effectiveness, impact on trade as well as the direct and indirect costs of the policy. This was a joint evaluation by Better Border Security (B3) scientists and overseas colleagues in collaboration with the National Centre for Ecological Analysis and Synthesis (NCEAS) at the University of California.

While ISPM 15 is unlikely to stop future invasions entirely, the economic benefits are estimated to be in excess of $10 billion (USD) by 2050. Findings from this analysis have been accepted for publication in the prestigious journal Ecology, and can be used as a model to evaluate other phytosanitary measures.

The Asian longhorned beetle, *Anoplophora glabripennis*.

Research partners: B3, MPI, APHIS, IFQRG	**Investment:** Scion Core, NCEAS

HEALTHY SEEDLINGS SHOW GOOD DEFENCE AGAINST BARK BEETLES

Plant stress is widely thought to increase a plant's susceptibility to herbivore attack and damage. Our entomologists tested this hypothesis using the bark beetle, *Hylastes ater*, during its maturation feeding stage. The frequency of attack and resulting damage to seedlings was compared on artificially stressed and unstressed radiata pine seedlings in the field.

Surprisingly, twice as many unstressed radiata pine seedlings were attacked than stressed seedlings, but were better able to defend themselves through a strong resin response, suffering less damage and usually recovering. By contrast, the damage to stressed seedlings was greater, often resulting in stem girdling and death.

Although these results appear contrary to the plant-stress hypothesis, insects are thought to respond to plant stress differently according to their feeding guild. While bark beetles are typically secondary feeders, preferring weakened and deteriorating plants, it appears *Hylastes ater* behaves differently during maturation feeding, more like primary feeders such as defoliators. At this stage, presumably the nutritional benefits of healthy seedlings are important for sexual maturation and outweigh the disadvantages of moving to another plant following a resin response. The ability to select another plant is not an option during most of the beetle's life cycle when it is confined underneath bark, at which time it requires a weakened host.

These results tease apart the difference between the effects of seedling stress on beetle attack versus resulting damage. This emphasises the importance of ensuring maximum seedling health through selection of stock and careful planting methods.

Research partners: Kaingaroa Timberlands, Hancock Forest Management
Investment: Scion Core

Adult black pine bark beetles, *Hylastes ater*.

WASP MAY SOLVE EUCALYPTUS TORTOISE BEETLE PROBLEM

Despite considerable efforts, the eucalyptus tortoise beetle, *Paropsis charybdis*, continues to defoliate *Eucalyptus nitens* plantations throughout New Zealand. The beetle is slowing expansion of this valuable commercial forest species resource and regular applications of insecticide are required to manage its impact.

The fast growing *E. nitens* perform well in colder parts of New Zealand, producing a valuable fibre resource for high quality paper production in New Zealand and as an export commodity. Scion has been working with a number of research partners to scope potential biological control solutions to the on-going beetle problem in a two year project supported by MPI's Sustainable Farming Fund.

Results from the first year of research undertaken in Tasmania suggest the parasitoid wasp, *Eadya paropsidis*, may provide the answer. The wasp attacks the larvae of the beetles only in springtime, injecting its egg into one of the larva. The wasp larva then consumes the host before entering the ground for a year, emerging as an adult the following spring.

A second year of research is planned to confirm results and establish laboratory rearing methods for the wasp.

Research partners: Tasmanian Institute of Agriculture
Investment: Scion Core, SFF (MPI), Southwood Exports Ltd, FFA, FFR, CHH, FOA

TACKLING BRONZE BUG THREAT

The bronze bug, *Thaumastocoris peregrinus*, was discovered in Auckland last year through MPI's high risk site surveillance programme. The sap feeder is a significant pest of eucalypts, causing leaf discoloration, or 'winter bronzing' which can lead to premature leaf drop and branch death. Potential hosts include over 30 species of eucalypts. This Australian insect has spread rapidly in recent years and is now found in almost every major eucalypt growing region in the world.

At present, an eradication campaign is not supported in New Zealand but the bug remains a concern for eucalypt growers, farm foresters and local government with a popular amenity tree, *Eucalyptus nicholii*, severely affected. Two (*E. argophloia* and *E. camaldulensis*) of the six species identified to expand eucalypt plantations as part of the New Zealand Dryland Forests Initiative are also known hosts.

The bronze bug population is spreading but is still confined to the Auckland region. Dr Toni Withers is co-supervising a University of Auckland student to research the bug's ecology. The data will be used to predict how widespread the bronze bug will eventually be in New Zealand and assist the forest industry with longer term management decisions. Our entomologists are also investigating options for biological control.

Research partners: University of Auckland, supported by CHH	**Investment:** Scion Core, University of Auckland

PAVING THE WAY FORWARD FOR LOG EXPORTS

Scion is leading a collaborative STIMBR-MBIE co-funded programme to investigate alternatives to methyl bromide in the quarantine treatment of logs, opening the door to changes in New Zealand's log export regulations. Implementing a fumigation-free winter period will radically alter supply chain logistics, and its success will require buy-in from exporters, ports and marshalling companies.

Scion has begun liaising with key research partners within the export log industry to ensure any barriers to the adoption of a fumigation-free period can be overcome should future international trade negotiations prove successful.

Research partners: Asurequality, C3, Ernslaw One, IVS Ltd, NZ Forestry Managers, Quality Marshalling, Rayonier, Tenco, TPT, PF Olsen, PFP
Investment: Scion Core, MBIE, STIMBR

RAISING HEALTHY PESTS WILL GAIN INSIGHT INTO THEIR BEHAVIOUR

Scion's entomologists are working with Plant and Food Research to perfect the breeding protocols of common wood and bark eating pests to better understand their seasonal breeding cycles. This will help define the start-finish times of a non-fumigation period. Having a healthy collection of pests readily available also helps the development and testing of new phytosanitary treatments.

Both the golden-haired bark beetle (*Hylurgus ligniperda*) and the burnt pine longhorn beetle (*Arhopalus ferus*) have been successfully reared in the laboratory through a complete generation, and techniques optimised to induce egg-laying. The insects were fed an artificial diet and kept at a constant 25°C temperature, which dramatically increased their development rate by an average of 50% compared to those in the wild.

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

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

Research partners: Plant and Food Research	**Investment:** Scion Core, MBIE, STIMBR

DEFINING A FUMIGATION-FREE PERIOD FOR EXPORT LOGS

Our forest protection scientists are gathering detailed information on the distribution and population levels of forest pests throughout New Zealand in order to define a fumigation-free period during winter when there is little risk of pests on export logs. This is in response to mounting global pressure to reduce the use of methyl bromide as a fumigant.

The team has installed 135 traps, including 43 purpose-built 'separator traps', at 32 forest sites and five ports around the country. Separator traps allow the catch to be divided into hourly or daily periods so insect flight activities can be matched with meteorological conditions.

Although meaningful data to start negotiations with trading partners will not accrue for another two years, the trapping network is already having benefits. Up-to-date pest abundance data has been supplied to MPI to support its decision making, along with a two year historical data set compiled using funding from the STIMBR-Primary Growth Partnership and STIMBR-MBIE programme, to evaluate new post fumigation exposure periods. Long term, these data will be used to develop a pest prediction model to establish treatment programmes based on risk.

Along with reduced market access risks for our export forest products, this programme has the potential to save $6.1 million per year (based on 2011 statistics) through reduced fumigation costs, if a three month fumigant free period during winter can be achieved.

Research partners: MPI, STIMBR, Plant and Food Research, University of Canterbury, Bayesian Intelligence, port companies, forest owners
Investment: Scion Core, MBIE, STIMBR

RURAL FIRE RESEARCH

ONE-STOP-SHOP FOR FIRE WEATHER INFORMATION

The new national Fire Weather System (FWSYS) recently developed by Scion and NIWA will enable fire managers to focus more on fire prevention rather than fire management. The FWSYS provides a one-stop-shop for fire managers, providing them with access to fire weather information, forecast data and danger conditions across the country. It is the main tool used by the New Zealand Fire Service and rural fire managers to monitor changing conditions and potential fire outbreaks.

The system is based on NIWA's Eco-Connect climate forecasting platform, and utilises the latest research from our rural fire research group to provide current, historic and forecasted fire weather information to fire managers and the general public. Information includes national maps and tables of daily weather and fire danger conditions, as well as graphs or tables of hourly and daily data from more than 200 weather stations across the country.

The new system replaces the existing model which was last upgraded over 10 years ago. Out-dated computer hardware along with lack of fire weather forecasting capability meant current, archived and forecasted fire weather data needed to be obtained from three different systems. Today, NIWA's supercomputer models fire weather more accurately than the old system and overlays the forecasted weather over actual weather observations to show how well the forecasts are doing.

"I found EcoConnect to be a very good package to use during the fires in Northland earlier this year," says David Hunt, National Integration Coordinator for DOC. "The two and six day forecasts were excellent for identifying the predicted trends in the daily weather. The direct access to graphed fire behaviour indices also resulted in easy analysis for the incident planning team and operations staff.

"In regard to the roll out of the package and training, Scion in particular as well as NIWA and the NRFA, did an excellent job. Concurrent with the roll out there was refresher training on fire behaviour carried out by the Scion team. This was welcomed by the DOC staff I have talked to."

Rural fires cost the country about $100 million per year (BERL, *The Economic Cost of Wildfires*, 2009). The FWSYS will enable fire managers to better target fire prevention activities such as permit requirements, forest closures and public education, as well as heighten fire response readiness.

Improved fire weather information for landowners and the public will increase their awareness of, and response to fire danger conditions, and help reduce the number of fire starts and escapes, lowering firefighting costs and reducing the impact on our environment.

Research partners: NIWA, NZFSC
Investment: NZFSC via the NRFA

WILDFIRE COMMUNICATION FOR RURAL COMMUNITIES

Many rural communities are vulnerable to the risk of wildfires. Around 3,000 wildfires occurred each year between 1992 and 2007, and evidence suggests many communities are unaware of the risk these fires pose and ill prepared for their occurrence.

Lisa Langer, a social scientist from the Forest Systems Team, has embarked on a study to identify the most effective methods of communicating the risk of wildfires, preparedness for a wildfire event and mitigation to help minimise the number and impact of human-caused fires. Lisa has conducted three case studies in the Queenstown, Nelson and Wairoa areas, documenting each community's knowledge of and preparedness for wildfires. The study found that the ability to effectively communicate with at risk communities is not a simple one size fits all approach. Effective communication needs to be intimately linked with the nature of the communities.

The project is part of an Australasian Bushfire CRC programme, Communicating Risk, led by the RMIT University, Melbourne. The programme aims to develop a suite of tailored, multi-level communications strategies to help diverse communities in both countries respond to rural wildfire risk.

The team also worked with the Technical University of Lisbon to adapt this methodology to rural Portuguese communities. Results from similar case studies in Portugal will be analysed alongside the Scion study to produce learnings from different country perspectives.

Research partners: RMIT, Validatus Research, Technical University of Lisbon
Investment: Bushfire CRC, MBIE, NZ rural fire sector

SMALL DIFFERENCES CAN INFLUENCE FIRE BEHAVIOUR

Controlled back to back burns to clear land for forestry in the Waihopai Valley allowed our scientists to observe fire and smoke plume behaviour as well as the influence of local meteorology on fire development. The field studies also enabled the team to test our field protocols and equipment while being able to observe any problems and issues industry may face in the work environment that research can help to improve.

The burns also provided a good case study on the interaction between fuels, meteorology, smoke column development and fire behaviour. Cloud cover over the burn site caused a drop in temperature and increase in humidity, which noticeably suppressed the fire. Less solar radiation due to the cloud shade meant the fire environment could no longer provide enough energy to dry the fuel (in this case grass) and propagate the fire, demonstrating how even the smallest differences in weather can influence fire behaviour. Using previously developed carbon prediction models, the team was also able to show that the newly planted forest would uptake all the carbon dioxide (CO_2) emitted during the burn in one year when the trees were between four and five years old.

Research partners: University of Canterbury, in particular Department of Geography, Ernslaw One Ltd, Timbergrow, Marlborough Kaikoura Rural Fire District. Fire crew from other organisations such as DOC assisted on the day of the burns.
Investment: MBIE Rural Fire Research Programme

WILDINGS POSE GROWING FIRE HAZARD

The increasing spread of wilding conifers presents a growing number of problems for landowners as well as fire fighters and fire managers. Wildfires in dense wilding areas are thought to exhibit more extreme fire behaviour, be more difficult to suppress and present greater threats to lives and property.

A recent analysis conducted by our Rural Fire Research Team identified nine fire hazard stages and 44 possible fire behaviour models associated with wilding spread and control. The analysis revealed that over time, fuel characteristics change and, in combination with weather conditions, so too does potential fire behaviour.

Fire behaviour was shown to be dynamic. Fire weather conditions, as well as the stage of wilding invasion or treatment, have a strong effect on available fuel load and thus rate of spread and intensity of the fire. Lower density, medium height wilding stands and red standing trees (about two years following herbicide control treatment when the amount of biomass is unchanged but the forest floor is dead) represent greater fire hazards than tall, dense, green wilding stands. Herbicide use to control wildings is therefore predicted to increase fire risk.

Results of the analysis were presented at the annual national fire managers' conference (FRFANZ) and are also available on our website[1]. Further field research is proposed to validate the findings.

[1] *www.scionresearch.com/wilding-hazard*

Research partners: Nick Ledgard	**Investment:** NZFSC

FIRE DANGER INFORMATION AT THE FINGERTIPS

In March, members of the public will be able to check out the risk of fire for their current location at the click of a smartphone button. Fire researchers Veronica Clifford and Dr Richard Parker worked with University of Canterbury student Greg Signal to develop *Today's Fire Danger*, an Android smartphone 'app' that provides members of the public with free information about the prevailing fire risk for their location.

Tait Communications and the university sponsored Greg to develop the GPS-enabled prototype, which is being trialled by fire managers and fire fighters around the country. Scion's software engineering team is presently modifying the prototype to work with the new national Fire Weather System and to include any additional functionality recommended by industry.

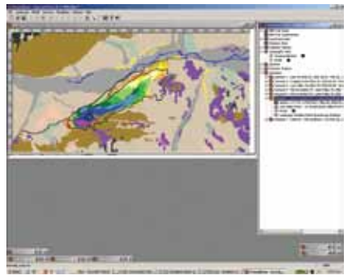
As well as showing today's fire danger, the final product will display the fire danger forecast for the next two days and information on actions that can be undertaken to minimise the risk of fires. The app will be a great addition to roadside fire danger boards, and it is hoped rural fire authorities will be able to use it to provide rural property owners with information on fire season status and relevant fire permit requirements for their property.

Scion is seeking feedback on the prototype. *Today's Fire Danger* can be downloaded from the Google Play app store on an Android smartphone or mobile device.

Research partners: Tait Communication, University of Canterbury Computer Science Department, NRFA
Investment: Tait Communications, University of Canterbury

PREPARING FOR THE FIRE SEASON

Fire researcher Veronica Clifford demonstrated the effectiveness of the fire growth simulation software, Prometheus, to rural fire managers as part of a 10-day secondment with the Department of Conservation. The Canadian software is a GIS-based fire growth simulation model that has been adapted by our Rural Fire Research Team for New Zealand conditions. The software is designed to enhance fire managers' planning and response to wildfires, resulting in fewer and less damaging fires.



Prometheus can be used to carry out 'what if' scenarios under different fire danger conditions, enabling fire managers to develop suitable suppression strategies. It can estimate where a fire is likely to spread based on the combination of fuel type, weather conditions, topography and fire behaviour models. Canterbury rural fire authorities have been able to use this information to identify resource requirements for different fire danger levels, and to justify appropriate fire prevention activities if early response is not possible.

During her secondment, Veronica was also able to train DOC staff in the application and use of Prometheus, while testing the software for the developers and producing tutorials for its use.

"Prometheus was used to significantly improve the strategic tactical fire management planning (STFMP) process. Predetermined response planning can be done using simple fire modelling equations, but better accuracy was achieved by using Prometheus to simulate fire growth across the landscape. It accounted for terrain and fuel type, enabling response to be targeted to a specific area or location on the ground." Heather Wakelin, Technical Support Officer, Department of Conservation.

Research partners: DOC	**Investment:** Scion Core

Phytophthora under the microscope.

FOREST DISEASES

NORFOLK ISLAND PINE TREATMENT TRIALS

The decline of several of Mount Maunganui's beachfront Norfolk Island pines is causing concern for local authorities and residents. The stately pines have been part of the Mount's landscape for some 50 years and are expected to continue growing for yet another 60 plus years. It is likely the severe drought earlier in the year, along with a combination of pathogens and site disturbances, has contributed to the trees' distress. Our Pathology Team is testing the trees for a number of pathogens and, in consultation with Tauranga City Council, conducting a preliminary treatment trial aimed at improving their overall health.

Trees have been injected with a combination of phosphite and micronutrients, applications routinely used in agriculture. Phosphite is a biodegradable salt widely used to control certain pathogens, including *Phytophthora* species, and the trees' response to phosphite will help diagnose potential causal agents. The micronutrients were applied to boost general tree health.

The treated trees will be closely monitored for signs of recovery over the next two years. If the treatment proves successful, this method may be used in further research aimed at improving the health of declining Norfolk Island pines around New Zealand.

Research Partners: Tauranga City Council	**Investment:** Scion Core

PREPARING FOR AN INVASION OF MYRTLE RUST

New Zealand's proximity to Australia makes it possible for a devastating pathogen of Myrtaceae species, *Puccinia psidii*, to enter New Zealand in the path of prevailing westerly winds.

The pathogen causes a disease known as myrtle rust. It has spread rapidly throughout Australia since it was discovered in 2010, affecting native and forestry tree species. Myrtle rust is difficult to contain and if introduced to New Zealand, would pose a serious threat to our native Myrtaceae - a genus containing pohutukawa, rata and manuka - as well as eucalyptus plantations and feijoa horticulture.

Scion's National Forestry Herbarium Curator Dr Matt Buys is developing a barcode library for a selection of Myrtaceae species in New Zealand, including those known to be susceptible to the disease or that have high cultural or economic value. In the event of a myrtle rust incursion, DNA barcoding provides a fast and robust method of identifying plant samples, especially ones that are morphologically very similar, without the need for all of the species' characteristics such as flower, seed and fruit.

To familiarise themselves with how the disease presents itself and determine the susceptibility of some of our Myrtaceae species to the disease, pathologist Dr Peter Scott and botanist Elizabeth Miller examined plantings of New Zealand Myrtaceae species throughout Australia where the disease is present. The rust was observed in the wild, in cultivation and in controlled experiments and the information is being documented to assist with appropriate mitigation strategies for New Zealand in case of incursion.

As a further biosecurity measure, our team has been working with MPI to test plant samples washed in ethanol, and DNA extracted from plants contaminated with myrtle rust to see if it was possible to identify the host plant from these samples. Good results were achieved from both samples. This will enable Scion's Diagnostics Team to assist MPI should an incursion occur without risk of spreading the disease.

According to Dr Lisa Ward, Manager Virology and Post Entry Quarantine at MPI, "this data is really useful and will enable us to make some more concrete decisions on the best way to proceed with host identification during a myrtle rust response."

Research Partners: B3	**Investment:** Scion Core, MPI

FUNDING BOOST FOR *PHYTOPHTHORA* RESEARCH

Phytophthora species pose major challenges to global biosecurity. The pathogens are known to affect an increasingly wide range of hosts worldwide and the rapid movement of organic material between countries has escalated the proliferation of *Phytophthora* related diseases. The spread of arboreal *Phytophthora* species, in particular, is occurring at such a rate that conventional approaches to plant breeding and disease management are unable to respond fast enough.

Scion has been allocated $10 million funding from MBIE over the next six years, with significant co-funding from sector groups, to lead collaborative research that will combine a multi-pathogen-host model with metabolic and genetic analysis to identify hosts that have a broad resilience to a number of *Phytophthora* species rather than to just one species.

Our research will focus on radiata pine, kauri and apple - species that are currently affected by *Phytophthora* diseases and that are of significant economic and cultural value to New Zealand.

What is *Phytophthora*?

Phytophthora is a genus of soil or air borne plant pathogens. Worldwide, there are more than 120 described species known to cause plant diseases and some have been the cause of devastating global epidemics, such as the Irish potato famine, and numerous forest and natural ecosystem declines.

Distribution and impact of these pathogens is changing rapidly. Ten years ago there were no known foliar diseases on forest conifers; since then, two significant *Phytophthora* diseases have emerged on radiata pine for which the causal agents, *P. pluvialis* and *P. pinifolia*, are new to science.

What impact does *Phytophthora* have on New Zealand?

There are three major *Phytophthora* diseases currently affecting our primary industries or conservation estates:

- Red needle cast (caused by *P. pluvialis*) is a new disease of radiata pine, first recorded in 2008. In isolated cases, it reduces annual productivity by nearly 40% in the growth year following heavy infection.
- Crown and collar rots in apples (*P. cinnamomi, P. cactorum* and *P. cryptogea*) may result in up to 20% tree loss during establishment, and ongoing root damage and tree losses under wet conditions.
- The threat also goes beyond our horticultural and forestry industries, impacting on indigenous and amenity trees with a wide range of social, aesthetic, cultural and environmental benefits. At present, our iconic kauri is fighting for survival against *P.* taxon Agathis (PTA), the cause of kauri dieback.

Scientists are concerned not only about the imminent impacts of these established diseases on New Zealand's trees, but also of the potential for further introductions of new *Phytophthora* pathogens with broad host ranges that may affect various primary sectors, compounding economic, social and cultural losses.

What are we doing to combat *Phytophthora*?

Scion is taking a genus-wide approach to disease breeding, management and research. The project builds on our existing programmes for red needle cast, kauri dieback and other *Phytophthora* diseases.

"As part of our MBIE funded project, we intend to screen breeding lines of radiata pine, kauri and apples against a range of *Phytophthora* species," says Dr Nari Williams, Forest Pathologist and national coordinator of the *Phytophthora* research project. "If found, susceptible and tolerant lines of each host will be selected and the interaction between

Phytophthora sporangia.

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.

"This could lead to the establishment of a breeding programme for resistance against a whole range of *Phytophthora* species, using material with durable resistance for application in commercial production and revegetation programmes."

Eight *Phytophthora* species have been selected for this multi-pathogen-host model that straddle the forestry and horticulture industries, and natural and urban estates. The three host species targeted are radiata pine, kauri and apples.

"Red needle cast of radiata pine will be our first priority. For kauri, fast tracking screening programmes to identify natural resistance could prove to be a lifeline for this ancient and extremely vulnerable species," says Nari.

Who else is involved?

This is a highly collaborative project that encompasses Scion's Forest Protection, Forest Genetics and Biotransformation Teams, and includes key national and international researchers.

Scion will be working with the Radiata Pine Breeding Company to deploy resilient radiata pine. Apple selection and screening will be implemented through Plant and Food Research in a joint project with IFO, a French company that evaluates and commercialises rootstocks.

Scion will work with local Māori groups, DOC and members of the Kauri Dieback Joint Agency Response (KDJAR) on the development of kauri screening and propagation channels.

Other national collaborators include Landcare Research, The Bio-Protection Research Centre, NZ Genomics Ltd, University of Auckland and Massey University. Internationally we will be working with Murdoch University, Australia; the University of British Columbia, Canada; Oregon State University, USA; and the University of Algarve, Portugal.

This project offers New Zealand the opportunity to become world leaders in *Phytophthora* research.

Research Partners: Plant and Food Research, Landcare Research

Funding: Scion Core, FOA, MBIE, RPBC, KDJAR, The Bio-Protection Research Centre

PHYTOPHTHORA REVEALED IN HISTORICAL SAMPLES

Phytophthora related diseases may have been simmering undetected in our plantation forests for longer than scientists first thought. Physiological needle blight is a disease in radiata pine that was first described at a time when *Phytophthora* species were thought to be associated only with soils and not cause foliar disease. However, there is recent speculation that the disease may be caused by a *Phytophthora* species such as *P. kernoviae*.

While it is known that *P. kernoviae* has been present in New Zealand for at least 50 years, it is not known how long the causal agent for red needle cast, *P. pluvialis*, has been present. Determining the length of time an organism has been present, or if it is newly introduced, will help our scientists build a comprehensive picture of the origins and characteristics of these pathogens.

To try and answer these questions, Molecular Forest Pathologist Dr Rebecca McDougal has been testing for the presence of *Phytophthora* DNA in selected samples from our mycological herbarium, taken between 1950 and 2000, that were associated with foliar diseases. In addition, samples from our Veritec laboratory collected for nutrient analyses were also analysed.

Eight of the 49 samples from the mycological herbarium contained *Phytophthora* DNA, three of which were *P. kernoviae*. Surprisingly, analysis of Veritec laboratory samples also revealed the presence of *Phytophthora* species dating back to the 1970s, with *P. kernoviae* identified in radiata pine as early as 1986.

Phytophthora pluvialis was not detected in any of the samples tested.

Investment: Scion Core, FOA

FIGHTING TO SAVE OUR KAURI

Kauri dieback, or *Phytophthora* taxon Agathis (PTA), is a fungus-like disease found 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 often too late to save them. However, the disease may be managed using chemical techniques.

What is kauri dieback disease?

Phytophthora taxon Agathis was formerly identified in New Zealand in 2008, although it was first recorded in 1974. At this stage, little is known about the disease or how long it takes for a tree to show signs of infection. The first signs of disease are often bleeding lesions on the trunk, yellowing and thinning of the canopy and dead branches. This can differ between sites; each population of kauri is distinct and some may be more susceptible or resistant to the disease than others.

The pathogen is soil based and can spread easily through the transfer of organic matter by people, animals or the transfer of plants from one location to another.

The pathogen has been found in the Northland and Auckland regions, and on Great Barrier Island. Many infected trees have died with thousands succumbing in the past decade.

What is Scion doing to help save our kauri?

Our research into kauri dieback is part of the wider MBIE funded project to tackle the *Phytophthora* problem for New Zealand (*refer Funding boost for* Phytophthora *research*). It involves identifying resistance within the kauri population, developing procedures to deactivate *Phytophthora* resting structures such as oospores, diagnostics and technical support.

"We are working with local iwi, the Kauri Dieback Joint Agency Response and project collaborators to determine if there is any natural resistance to kauri dieback within the native population of kauri," says Dr Nari Williams. "We will screen breeding lines of kauri against a range of *Phytophthora* species and breed for resistance to a whole suite of *Phytophthora* species, using resistant material to revegetate populations.

"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 kauri forests."

Research Partners: KDJAR, Auckland Council, Landcare Research, Plant and Food Research

Investment: MBIE, The Bio-Protection Research Centre

KAURI DIEBACK SYMPOSIUM

The first annual Kauri Dieback Symposium was held at the University of Auckland in November 2013. Led by Scion Pathologist Dr Peter Scott, the free public event attracted over 140 participants eager to engage in discussion with land managers, pathologists, ecologists and social scientists working to protect and conserve kauri. Scion scientists Dr Scott, Dr Nari Williams and Greg Steward presented their work on *Phytophthora* species affecting kauri and radiata pine.

The symposium generated vigorous discussion between community members and presenters with participants keen to see the symposium become an annual occurrence. The event was followed by a field visit to the Albany kauri forest where participants saw first-hand the destruction of kauri dieback disease on trees that have been standing for hundreds of years.

The symposium was sponsored by Scion, Auckland Council, MPI, The Bio-Protection Centre and Plant and Food Research. Scion is committed to supporting future events as an important link between stakeholders, our research programme and effective disease management.

RED NEEDLE CAST RESEARCH GIVEN HIGH PRIORITY

Red needle cast is a recent addition to the growing list of *Phytophthora* related diseases affecting New Zealand's agroforestry and horticulture industries.

Research into red needle cast and other foliage diseases is given high priority by Scion and the forest industry. This year we have made significant inroads into developing a viable chemical control for red needle cast and an experimental programme is in place to identify strains of radiata pine with genetic resistance to the disease *(refer Funding boost for* Phytophthora *research)*. This programme brings together scientists from both forest genetics and forest protection disciplines in a concerted effort to control the disease.

Chemical control of *P. pluvialis*

Trials to identify chemical treatments for red needle cast show phosphite to be effective in reducing the number and length of lesions caused by *P. pluvialis*. Latest results also indicate these effects persist for up to six months post-application. This is a positive step toward the development of a short-term management strategy for red needle cast. Sampling of existing trials continues so that we can determine the longevity of the response to phosphite.

Now the effectiveness of phosphite has been demonstrated, we will begin scale-up trials to determine optimum dosage and timing of application.

No threat posed for exports

Our research shows that two *Phytophthora* species do not threaten New Zealand's log trade.

Recent studies using artificial inoculation techniques in radiata pine, show that *P. pluvialis* and *P. kernoviae* do not colonise wood. Both pathogens were unable to colonise succulent branch material tested during field trials. This supports research reported in the 2012 Annual Science Report where *P. pluvialis* and *P. kernoviae* spores did not contaminate, nor survive on, logs in natural and artificial conditions. Two research papers on this and the status of *P. pluvialis* are in press and will be published in early 2014.

Breeding for resistance

Our Forest Genetics and Forest Protection Teams have been working with the Radiata Pine Breeding Company (RPBC) to develop a screening system for red needle cast-tolerant germplasm selection. This will allow the identification of highly resistant and tolerant germplasm, and the identification of highly susceptible germplasm that can subsequently be removed or deployed elsewhere.

Previous work undertaken by Forest Genetics and the RPBC has shown resistance to the disease appears to be moderately heritable. The team is using a two-pronged approach to search for resistance. Mature radiata pine genotypes are being screened by inoculating plants in the field and detached needles in the laboratory. 'Elite' clonal material – material that has been developed by the RPBC for future plantation forestry – is also being screened for its resistance to the disease and as a potential benchmark for future work.

"The ability to identify trees within our breeding programme with a heritable tolerance to certain diseases allows us to plant robust trees to disease prone sites," says Science Leader for Forest Genetics, Dr Heidi Dungey. "Furthermore we can use targeted breeding approaches to improve the disease tolerance of other valuable germplasm."

"We are also looking at alternative options for screening material that is remote from the laboratory, such as clonal archives or seed orchards in the South Island," adds Pathology Research Leader Dr Rebecca Ganley. "At the moment we are limited to using locally available genetic material, as the inoculation techniques rely on spores that are only viable for a few hours. That's a very narrow window in which to work and makes any large field inoculations very challenging."

Research Partners: RPBC, FOA
Investment: Scion Core, MBIE, RPBC, FOA

GENETIC RESEARCH INTO DOTHISTROMA NEEDLE BLIGHT

Identifying and analysing effector genes in the fungus *Dothistroma septosporum* that are responsible for causing dothistroma needle blight could potentially be used to screen for resistant germplasm. This is the aim of research currently being undertaken by Massey University PhD student Yanan (Melissa) Guo, who works with Dr Rosie Bradshaw. Melissa's research is fully funded by Scion and she is co-supervised by Pathology Research Leader Dr Rebecca Ganley.

Effector genes produce proteins that can trigger a defence response in the host species, and are known to be the determining factor of many plant-pathogen interactions. Identifying these genes in *D. septosporum* and gaining a better understanding of their function will provide valuable information on dothistroma needle blight development. It will also develop methods that can be used in future research.

Melissa's PhD finishes in September 2014, but Scion will fund another doctoral student to continue her research.

NEW INOCULATION CHAMBER AIDS FOLIAR DISEASE RESEARCH

Scion recently constructed a purpose-built chamber to undertake plant inoculations for foliar disease research.

The inoculation chamber allows for a clean environment to reduce the risk of contamination. It is equipped with sprinklers and fogging units. Environmental conditions including temperature, humidity and lighting can be controlled.

PEST MANAGEMENT

DETERMINING THE IMPACT OF HERBICIDES ON THE FOREST ENVIRONMENT

Forest Systems scientists Loretta Garrett and Dr Brenda Baillie are working with the Pest Management Team to evaluate the environmental impact of terbuthylazine and hexazinone in planted forests. These chemicals are two of the most widely used herbicides in New Zealand planted forests and provide excellent control of major weeds. Although both are listed as highly hazardous by the Forest Stewardship Council (FSC), there is no published research on the impact of these herbicides to the planted forest environment in New Zealand, only comparable data for research conducted elsewhere.

During last summer's growing season, the team conducted field trials to monitor concentrations of the herbicides before and after spraying. Measurements were taken from the forest floor litter and soil, stream water, stream sediment and stream algae. The results showed that after the initial application, herbicide concentrations in the following six months were low in the stream water, sediment and algae, and quickly degraded in the litter and soil, therefore posing a low risk to the environment. However, the trials were conducted during a period of widespread drought and the team is looking to reassess this information during normal and high rainfall conditions.

At present, forest growers are granted permission to use the two herbicides under certain restrictions while further research is being undertaken into alternative chemical vegetation control.

Research Partners: Timberlands Ltd	**Funding:** AgResearch

MINIMISING THE ENVIRONMENTAL IMPACT OF WEED CONTROL

In partnership with MPI and the Forest Stewardship Council Cluster Group, Scion implemented field trials in spring 2012 to screen a number of herbicide mixes as possible replacements for terbuthylazine and hexazinone. After one year, results indicate the best alternative herbicide mixes to the current industry standard include treatments where terbuthylazine has been applied in combination with mesotrione, triclopyr or clopyralid, or where a mixture of triclopyr, clopyralid and haloxyfop has been applied.

The status of terbuthylazine with regards to the FSC is still in question, and trial results indicate that its use, in combination with alternatives to hexazinone, will potentially provide acceptable weed control. Subject to further testing, this result provides the forest industry with potential chemical weed control options that are compliant with FSC certification criteria, should the status of terbuthylazine be changed to 'not restricted'.

Research Partners: MPI, FSC	**Funding:** MBIE, FSC Cluster Group, FFR, SFF

A TARGETED APPROACH TO AERIAL SPRAY APPLICATION

Our Pest Management Team assisted MPI in an eradication programme for the eucalyptus leaf beetle (*Paropsisterna beata*). The beetle defoliates the tree canopy and if not contained, could have a serious impact on New Zealand's hardwood and woodlot stands. The eradication site, in a small valley near Upper Hutt, was complex with host trees located between houses and within steep terrain. This required a novel approach of insecticide application to prevent drift onto nearby homes and gardens.

The team developed and tested a new aerial spray method, the spot gun, to target key host trees in sensitive locations. This was approved by MPI.

The spot gun method was further modified to meet Civil Aviation Authority standards in time for the spring eucalyptus leaf beetle eradication programme. Scion's Stefan Gous teamed up with Don Hammond of HRML and HeliResources to modify a standard aerial spray boom to produce an output of spray equivalent to the spot gun method. The spray was a stream of larger drops driven into the tree canopy by the helicopter downwash resulting in little aerosol drift away from the targeted tree. Feedback on spot-boom spraying from MPI was positive, and subsequent surveys of the area have found no live insects.

The spot gun and spot-boom aerial spray methods are the first tools in a 'toolkit' of spraying techniques we hope to further develop and optimise over the next few years. The toolkit will provide a range of aerial spray application methods that can be used at or near sensitive areas.

Spray deposition modelling

Forest Systems scientist Dr Jenny Grace also finalised the AGDISP model version testing protocol. AGDISP is a spray deposition model developed by the US Forest Service and adapted by Scion. It allows for exploration of effective aerial spray programmes based on spray release height, droplet size, aircraft type and velocity, and canopy type and density.

Scion is now one of the major developers of the research version of the US Forest Service AGDISP model, and there are several on-going projects to develop new algorithms and code for the model. The AGDISP testing protocol is essential to track these changes and develop a history of known changes and resulting model output.

Drs Schou, Strand and Richardson have been invited by the US Forest Service to present at the SERG International Pest Management conference in February 2014.

Research Partners: B3, MPI, HRML, US Forest Service, Lincoln Agritech Ltd., Plant Protection Chemistry NZ

Funding: Scion Core, MPI Biosecurity and Animal Welfare Operational Research Fund and Response Group, US Forest Service

NEW TRACK SPRAYER PROVIDES MORE REALISTIC SPRAY SIMULATION

Scion's new precision track sprayer provides a novel approach to conducting spray deposition research. The facility has expanded our spray deposition research capabilities, and allows for a more realistic simulation of spray deposition and data collection in a large, yet enclosed laboratory environment.

The track sprayer was developed as part of the wider MBIE project "Protecting New Zealand's Environment from Pesticide Exposure", contracted to Scion through Lincoln Agritech Ltd. It includes a four metre spray boom attached four metres above the ground to a fixed track. The sprayer boom can currently reach speeds of up to 18 km/hr and the 12 metre track can be extended in the future to allow for greater speeds that better represent aerial spray applications. Scientists are able to adjust spray release speed and droplet size, and use the testing zone to look at the effect of canopy type and density on spray deposition.

The controlled environment allows for testing of many elements that influence spray deposition and retention on the canopy. Using dye tracers and artificial collectors, spray deposition can be quantified in, and on, various plant canopies.

Track sprayer results can be used to narrow and refine costly field spray deposition studies. The MBIE project team, which includes Scion, Lincoln Agritech, PPCNZ, US Forest Service and other international scientists, will also use data from the track sprayer to improve spray deposition models such as AGDISP. The research aim is to reduce off-target spray movement such as drift, soil transport and volatilisation.

In the future, this facility will be used to optimise dose-response curves for precision application of pesticides to control invasive insects, pathogens and weeds. The large scale of the facility provides a unique opportunity to investigate the interaction of spray technology with pesticide activity in a variety of live plant canopies.

The facility and the AGDISP model have already been successfully used by Forest Protection scientists to assist MPI with developing effective aerial spray programmes for the eucalyptus leaf browser beetle (*Paropsisterna beata*) and for research on control of needle diseases.

Research partners: Lincoln Agritech, PPCNZ, US Forest Service

Investment: Scion Core, MBIE

FOREST HEALTH DIAGNOSTICS

Exotic, urban and indigenous forests are surveyed for new pests via MPI's high risk site surveillance programme and the FOA forest surveillance scheme. Scion's Forest Health Reference Laboratory diagnosticians have made over 1,200 identifications this year, including two new to New Zealand fungi.

We are the country's premier group for diagnosing insect pests and fungal diseases of trees, and for identifying forestry species. Assets include a transitional and containment facility, a molecular diagnostic laboratory, and extensive databases and reference collections for insects, fungi and woody plants.

The Forest Health Database, now shared between Scion and the FOA, contains over 190,000 records of forest insects and diseases primarily from surveys since 1960. Scion's BUGS database contains information about wood and bark boring insects that have been intercepted at New Zealand's border from 1948 to 2000. These data are invaluable in monitoring insects and diseases in New Zealand and determining likely pathways of incursion for new species.

Collections

Scion's insect collection is an essential research, diagnostic and archival resource. It contains approximately 100,000 specimens, consisting mainly of forest insects and insects affecting timber in use. The collection contains adults gathered during forest surveys and trapping, and those reared from field-collected caterpillars and wood boring larvae, as well as the many insects discovered during quarantine inspections of imported timbers, casewood and dunnage.

Scion's mycological herbarium contains over 3,000 fungi specimens along with algae and lichens from New Zealand native forests, exotic plantations and urban amenity plantings. The living culture collection holds over 1,600 isolates of a similar range of fungi.

Our National Forestry Herbarium houses one of the country's largest collections of cultivated and indigenous tree species. The facility contains some 30,000 catalogued, geo-referenced specimens. The collection is currently being photographed to expand the online database and make the collection more accessible to forest industries.

Developments in Scion's diagnostic capabilities this year include two molecular identification projects. The Herbarium Team has been working with the Forest Protection scientists to DNA barcode species belonging to the myrtle family in New Zealand to aid rapid identification should an incursion of myrtle rust occur *(see Preparing for an invasion of myrtle rust)*.

In addition, a DNA-based method using high resolution melting (HRM) analysis is being developed for differentiation of *Phytophthora* and *Botryosphaeria* species which are often encountered in diagnostic samples and can, at times, be difficult to identify by traditional techniques. This is a rapid high-throughput method which can identify species faster than traditional methods.

Research partners: MPI, AsureQuality, SPS Biosecurity, NZFOA

Investment: Scion Core, MPI, FOA

SIGNIFICANT PUBLICATIONS

Avila, G. A., Berndt, L. A., & Holwell, G. I. (2013). Dispersal behavior of the parasitic wasp *Cotesia urabae* (Hymenoptera: Braconidae): A recently introduced biocontrol agent for the control of *Uraba lugens* (Lepidoptera: Nolidae) in New Zealand. *Biological Control, 66*, 166-172.

Bader, M. K. F., Leuzinger, S., Keel, S. G., Siegwolf, R. T. W., Hagedorn, F., Schleppi, P., & Körner, C. (2013). Central European hardwood trees in a high-CO_2 future: Synthesis of an 8-year forest canopy CO_2 enrichment project. *Journal of Ecology, 101*, 1509-1519.

Barbaro, L., Giffard, B., Charbonnier, Y., van Halder, I., & Brockerhoff, E. G. (2013). Bird functional diversity enhances insectivory at forest edges: A transcontinental experiment. *Diversity and Distributions, 20*, 149-159.

Barnagaud, J. Y., Barbaro, L., Papaïx, J., Deconchat, M., & Brockerhoff, E. G. (2013). Habitat filtering by landscape and local forest composition in native and exotic New Zealand birds. *Ecology, 95*, 78-87. DOI:10.1890/13-0791.1.

Brockerhoff, E. G., Kimberley, M., Liebhold, A. M., Haack, R. A., & Cavey, J. (2013). Predicting how altering propagule pressure changes establishment rates of biological invaders across species pools. *Ecology*. DOI:10.1890/13-0465.1. *In press*.

Bulman, L. S., Dick, M. A., Ganley, R. J., McDougal, R., Schwelm, A., & Bradshaw, R. E. (2013). Dothistroma needle blight. In P. Gonthier & G. Nicolotti (Eds.), *Infectious Forest Diseases* (pp. 436-457). Wallingford, UK: CABI.

Castagneyrol, B., Jactel, H. Vacher, C., Brockerhoff, E. G., & Koricheva, J. (2013). Effects of plant phylogenetic diversity on herbivory depend on herbivore specialization. *Journal of Applied Ecology*. DOI:10.1111/1365-2664.12175. *In press*.

Clifford, V. R., Pearce, H. G., & Anderson, S. A. J. (2013). *Guide to New Zealand fuels – a technical guide for selecting the most appropriate fuel type for fire behaviour predictions*. Christchurch, New Zealand: Scion.

Epanchin-Niell, R. S., Brockerhoff, E. G., Kean, J. M., & Turner, J. A. (2013). Designing cost-efficient surveillance for early detection and control of multiple biological invaders. *Ecological Applications*. DOI:10.1890/13-1331.1. *In press*.

Goodrick, S. L., Achtemeier, G. L., Larkin, N. K., Liu, Y., & Strand, T. M. (2013). Modelling smoke transport from wildland fires: A review. *International Journal of Wildland Fire, 22*, 83-94.

Haines, M. L., Emberson, R. M., Sheppard, A., Syrett, P., Withers, T. M., & Worner, S. P. (2013). Implications of individual variation in insect behavior for host specificity testing in weed biocontrol. *Biocontrol, 58*(5), 703-713.

Iturritxa, E., Ganley, R. J., Raposo, R., García-Serna, I., Mesanza, N., Kirkpatrick, S. C., & Gordon, T. R. (2013). Resistance levels of Spanish conifers against *Fusarium circinatum and Diplodia pinea. Forest Pathology, 43*, 488-495.

Kabir, M. S., Ganley, R. J., & Bradshaw, R. E. (2013). An improved artificial pathogenicity assay for Dothistroma needle blight on *Pinus radiata*. *Australasian Plant Pathology, 42*, 503-510.

Kay, M. K. (2013). Defoliator resistance in the natural prevanances of *Pinus radiata*. In K. V. Wurms, A. J. Popay, N. L. Bell & M. V. Jaspers (Eds.), *Utilising plant defence for pest control*, (pp. 83-91). Havelock North, New Zealand: New Zealand Plant Protection Society.

Kriticos, D. J., Leriche, A., Palmer, D. J., Cook, D. C., Brockerhoff, E. G., Stephens, A. E. A., & Watt, M. S. (2013). Linking climate suitability, spread rates and host-impact when estimating the potential costs of invasive pests. *PLoS One, 8*(2), e54861.

Larkin, N. K., Raffuse, S. M., & Strand, T. M. (2013). Wildland fire emissions, carbon, and climate: U.S. emissions inventories. *Forest Ecology and Management*. DOI:10.1016/j.foreco.(2013).09.012. *In press*.

Li, A. Y., Williams, N. M., Fenwick, S. G., Hardy, G. E. S. J., & Adams, P. J. (2013). Potential for dissemination of *Phytophthora cinnamomi* by feral pigs via ingestion of infected plant material. *Biological Invasions*. DOI:10.1007/s10530-013-0535-7. *In press*.

McCarthy, J. K., Brockerhoff, E. G., & Didham, R. K. (2013). An experimental test of insect-mediated colonisation of damaged *Pinus radiata* trees by sapstain fungi. *PLoS One, 8*(2), e55692.

McCarthy, J. K., Didham, R. K., Brockerhoff, E. G., van Bysterveldt, K. A., & Varsani, A. (2013). High-resolution DNA melt-curve analysis for cost-effective mass screening of pairwise species interactions. *Molecular Ecology Resources, 13*(5), 908-917.

Moffat, A. J., & Pearce, H. G. (2013). Contrasting approaches to forest fire risk in New Zealand and Great Britain. *Scottish Forestry, 67*(4), 10-17.

Pawson, S. M., Brin, A., Brockerhoff, E. G., Lamb, D., Payn, T. W., Paquette, A., & Parrotta, J. A. (2013). Plantation forests, climate change and biodiversity. *Biodiversity and Conservation, 22*, 1203-1227.

Ramsfield, T. D., Power, M. W. P., & Kimberley, M. O. (2013). The relationship between pruning and the incidence of *Neonectria fuckeliana* in *Pinus radiata*. *New Zealand Journal of Forestry Science, 43*. DOI:10.1186/1179-5395-43-13.

Rolando, C. A., Garrett, L. G., Baillie, B. R., & Watt, M. S. (2013). A survey of herbicide use and a review of environmental fate in New Zealand planted forests. *New Zealand Journal of Forestry Science, 43*. DOI:10.1186/1179-5395-43-17.

Scott, P. M., Burgess, T., & Hardy, G. (2013). Globalization and Phytophthora. In: K. Lamour (Ed.), *Phytophthora: a global perspective*. Cambridge, UK: CAB International.

Scott, P. M., Dell, B., Shearer, B. L., Barber, P. A., & Hardy, G. E. S. J. (2013). Phosphite and nutrient applications as explorative tools to identify possible factors associated with *Eucalyptus gomphocephala* decline in South-Western Australia. *Australasian Plant Pathology, 42*(6), 701-711.

Scott, P. M., Shearer, B. L., Barber, P. A., & Hardy, G. E. S. J. (2013). Relationships between the crown health, fine root and ectomycorrhizae density of declining *Eucalyptus gomphocephala*. *Australasian Plant Pathology, 42*(2), 121-131.

Simpson, C., Pearce, G., & Clifford, V. (2013). High-resolution WRF simulation of fire weather associated with the Mt Cook Station fire. In J. Piantadosi, R. S. Anderssen & J.Boland (Eds), *20th International Congress on Modelling and Simulation MODSIM (2013)* (pp. 277-283). Canberra, ACT, Australia: Modelling and Simulation Society of Australia and New Zealand.

Simpson, C. C., Pearce, H. G., Sturman, A. P., & Zawar-Reza, P. (2013). Verification of WRF modelled fire weather in 2009-10 New Zealand fire season. *International Journal of Wildland Fire*. DOI:10.1071/WF12152. *In press*.

Smaill, S. J., & Walbert, K. (2013). Fertilizer and fungicide use increases the abundance of less beneficial ectomycorrhizal species in a seedling nursery. *Applied Soil Ecology, 65*, 60-64.

Withers, T. M., Watson, M. C., Watt, M. S., Nelson, T. L., Harper, L. A., & Hurst, M. R. H. (2013). Laboratory bioassays of new synthetic and microbial insecticides to control eucalyptus tortoise beetle *Paropsis charybdis*. *New Zealand Plant Protection, 66*, 138-147.

Zimmermann, U., Bitter, R., Schüttler, A., Ehrenberger, W., Rüger, S., Bramley, H., Siddique, K., Arend, M., & Bader, M. K. F. (2013). Advanced plant-based, internet-sensor technology gives new insights into hydraulic plant functioning. *Acta Horticulturae, 991*, 313-320.

FOREST PROTECTION STAFF LIST

General Manager

Brian Richardson
Pest Management Specialist
BSc Hons (Biology), MSc (Bio-Aeronautics), PhD (Forest Ecology)

Science Leader

Lindsay Bulman
Pathologist
NZCS (Biology)

Team Manager

Katrin Webb
Pathologist
MSc (Biology), PhD (Mycology)

Administration

Rose O'Brien
Management Assistant
Dipl. Bus. Computing

Principal Scientist

Eckehard Brockerhoff
Entomologist
MSc (Biology), PhD (Forest Entomology)

Biometrician

Martin Bader
Biometrician/Plant Physiologist
MSc (Plant Ecophysiology), MSc (Geography), PhD (Plant Ecology)

Entomology

Stephen Pawson
Research Leader
B. PRTM, BSc (Conservation and Ecology), M Appl Sc (Invertebrate Systematics), PhD (Zoology)

Belinda Gresham
Senior Technician
BSc Tech (Biological Sciences)

Jessica Kerr
Senior Technician
BSc (Biological Sciences), MSc (Ecology)

Nicolas Meurisse
Entomologist
BSc (Bioengineering), MSc (Bioengineering), PhD(Agronomical Sciences and Biological Engineering)

Brooke O'Connor
Field & Laboratory Technician
BSc (Biology/Ecology)

Andrew Pugh
Technical Assistant
BSc (Bioprotection & Biosecurity), MSc (Hons) (Conservation & Ecology)

Cecilia Romo
Entomologist
BSc (Conservation Biology), PhD (Ecology)

Stephanie Sopow
Entomologist
BSc (Hons) (Biology), MScF (Forest Entomology)

Michelle Watson
Entomologist
BSc (Forest Ecology)

Toni Withers
Entomologist
BSc (Zoology), PhD (Plant Health)

Pathology

Rebecca Ganley
Research Leader
BSc (Genetics, Molecular Biology & Biochemistry), MSc (Genetics), PhD (Natural Resources)

Debra Bly
Laboratory Coordinator
NZCS (Chemistry & Microbiology)

Matt Buys
Plant Taxonomist
BSc (Hons) (Botany), MSc (Plant Ecology), PhD (Plant Systematics)

Anna Caird
Molecular Biologist
BSc (Microbiology), MSc (Plant Biotechnology)

Judy Gardner
Diagnostic Technician
BSc (Mathematics)

Ian Hood
Pathologist
BSc (Botany/Chemistry), MSc (Botany)

Wendy Hurren
Herbarium Technician

Rebecca McDougal
Molecular Forest Pathologist
BSc (Microbiology), MSc (Microbiology), PhD (Microbiology)

Elizabeth Miller
Assistant Herbarium Curator
BSc (Botany)

Tomoko Pearson
Technician
BAg (Soil Science)

Peter Scott
Forest Pathologist
Mycologist BSc (Hons) (Plant Pathology), PhD (Plant Pathology)

Pam Taylor
Containment Facilities Manager and Technician

Rita Tetenburg
Technician

Nari Williams
Forest Pathologist
BAgSci (Hons) (Integrated Pest Management), PhD (Biotechnology/Plant Pathology)

Pest Management

Carol Rolando
Research Leader
BSc (Hons) (Cell Biology), MSc (Botany), PhD (Biology)

Catherine Banham
Technical Assistant
National Certificate in Horticulture

Carolina Gous
Technician
B.A.MBK (Geography, Human Movement Science), Post Grad. Higher Education Dipl. Secondary Schools (Geography)

Stefan Gous
Pesticide Application & Vegetation Management Specialist
BSc (Botany/Zoology), BSc (Hons) (Ecophysiology), MSc (Forestry Vegetation Management)

Tia Uaea
Field Work Assistant

Liam Wright
Field Work Coordinator & Senior Technical Assistant
Dip. (Environmental Management)

Fire

Richard Parker
Research Leader
BSc (Zoology), PhD (Human Factors & Ergonomics)

Veronica Clifford
Fire Scientist
BSc (Biology), MSc (Biology)

Grant Pearce
Bushfire Scientist
BSc (Geography), MSc (Geography)

Tara Strand
Atmospheric Dispersion Modeller
BSc (Civil Engineering), MSc (Environmental Engineering), PhD (Civil Engineering, Atmospheric Science)

Email. All staff can be reached at firstname.lastname@scionresearch.com

GLOSSARY

APHIS	Animal and Plant Health Inspection Service, US Department of Agriculture
B3 ALLIANCE	Better Border Biosecurity Alliance
CHH	Carter Holt Harvey
CRC	Bushfire Cooperative Research Centre
DOC	Department of Conversation
FFA	Farm Forestry Association
FFPRI (JAPAN)	Forestry and Forest Products Research Institute Japan
FFR	Future Forests Research
FGLT	Forest Growers Levy Trust
FRFANZ	Forest and Rural Fire Association of New Zealand Inc
FSC	Forest Stewardship Council
FWSYS	Fire Weather System
HRML	Hammond Resource Management Limited
INRA (FRANCE)	French National Institute for Agricultural Research
IFO (FRANCE)	International Fruit Obtention
IFQRG	International Forestry Quarantine Research Group
IPSM	International Standards for Phytosanitary Measures
IUFRO	International Union of Forest Research Organisations
IVS Ltd	Independent Verification Services Limited
KDJAR	Kauri Dieback Joint Agency Response
MBIE	Ministry of Business, Innovation and Employment
MPI	Ministry for Primary Industries
NCEAS	National Centre for Ecological Analysis and Synthesis, University of California
NIWA	National Institute of Water and Atmospheric Research
NRFA	National Rural Fire Authority
NZFOA	New Zealand Forest Owners Association
NZFSC	New Zealand Fire Service Commission
PFP	Pacific Forest Products
PGP	Primary Growth Partnership
PPCNZ	Plant Protection Chemistry New Zealand
RMIT	Royal Melbourne Institute of Technology
RNC	Red Needle Cast
RPBC	Radiata Pine Breeding Company
Scion Core	Crown Research Institute Core Purpose Funding
SERG International	Association of forest management, regulatory and research agencies, and pesticide suppliers, interested in forest pest management.
SFF	Sustainable Farming Fund (MPI funding)
STFMP	Strategic Tactical Fire Management Plans
STIMBR	Stakeholders in Methyl Bromide Reduction Incorporated
TPT	TPT Forests Limited
USDA	United States Department of Agriculture

Scion, Te Papa Tipu Innovation Park, 49 Sala Street,
Private Bag 3020, Rotorua 3046, New Zealand.
Telephone +64 7 343 5899. Facsimile +64 7 348 0952

For further information contact
Dr Brian Richardson at brian.richardson@scionresearch.com

ISSN 2324-3562 (print)
ISSN 2324-3570 (online)

© 2014 NZ Forest Research Institute Ltd, trading as Scion