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Forest Biosecurity and Protection

ANNUAL SCIENCE REPORT 2011

As forests the world over face emerging biosecurity issues, it is important that Scion uses the best resources and skills available to ensure continued protection of New Zealand's natural resources.

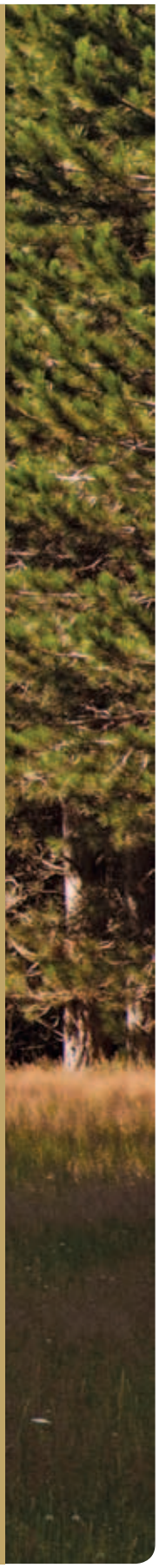
Forest Biosecurity and Protection

ANNUAL SCIENCE REPORT 2011

This report summarises forest biosecurity and protection activities undertaken by Scion during the 2011 calendar year.

Biosecurity is the exclusion, eradication, or effective management of risks posed by pests and diseases to the economy, environment and human health.

Cover photo: eucalypt tortoise beetle (*Paropsis charybdis*).



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Foreword

Scion has embarked on a new direction in forest biosecurity research following shifts in the operating environment for Crown Research Institutes (CRIs) and in forest sector priorities.

Changes for CRIs were driven by findings from a CRI Taskforce set up by Government to review how New Zealand's science capability can best be utilised for the national good.

As the CRI dedicated to forestry, Scion has clear responsibility, through its Statement of Core Purpose, for leading New Zealand's forest biosecurity, risk management and mitigation research. This scope includes fire research, which is an important risk for New Zealand's forests, rural areas and communities.

Recommendations from the CRI Taskforce have encouraged all CRIs to focus on the research priorities defined by their stakeholders. For Scion's biosecurity research, this means channelling more science effort into priorities identified by forest growers, the Ministry of Agriculture and Forestry (MAF) and other stakeholders. In-depth consultation in 2010 revealed a need for more focus on biosecurity research in distinct areas summarised on pages 3 and 4.

Needle diseases of radiata pine and Douglas-fir are seen as the highest priority forest health issue in New Zealand's commercial plantations. Although research efforts in the past by Scion have developed some management options for diseases such as dothistroma and cyclaneusma, there is a case for renewed effort to produce further productivity increases. Options include biological control using endophytes or perhaps viruses, and the application of a range of traditional and molecular genetics technologies. These methods could also reduce reliance on chemical sprays.

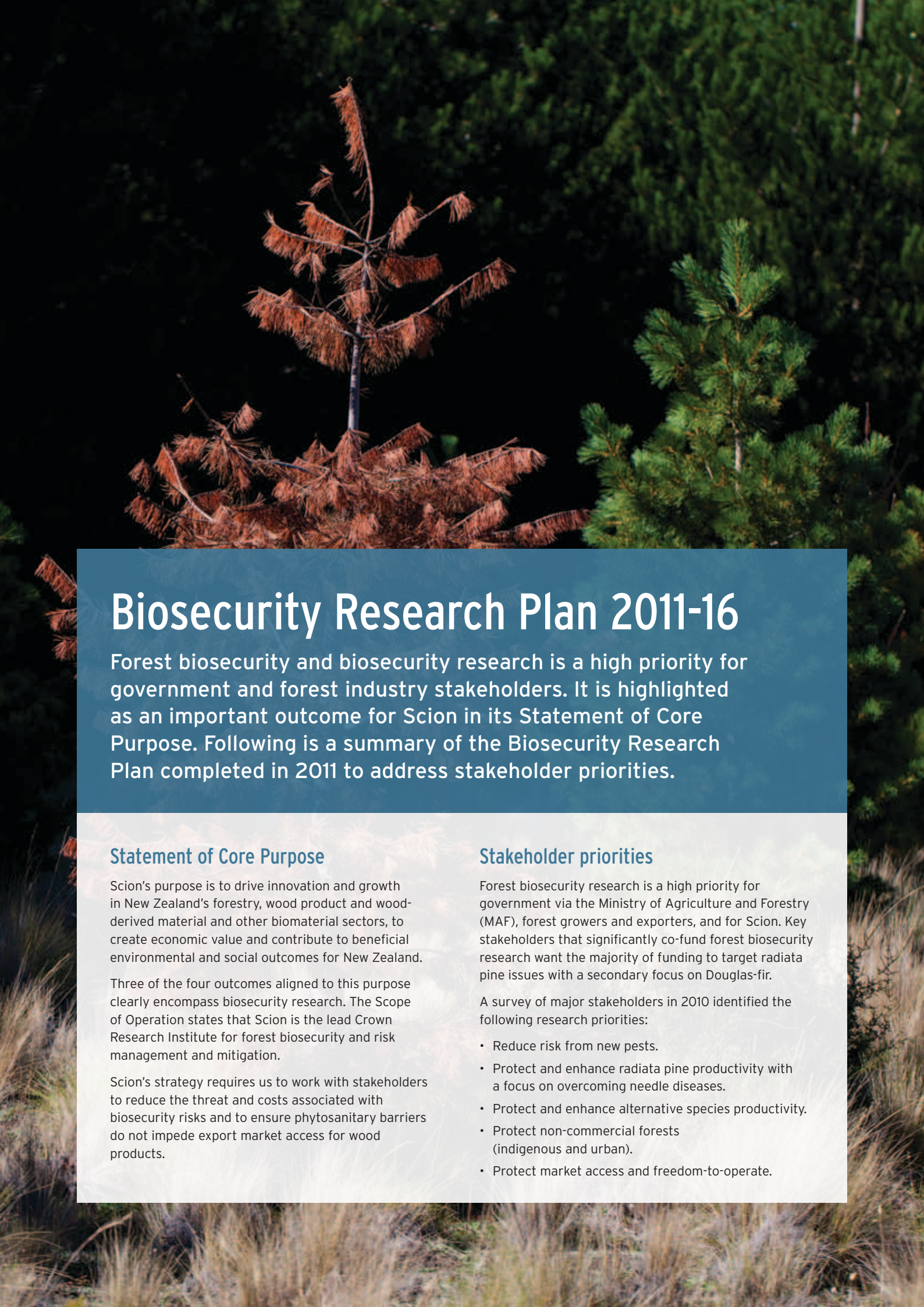
Reducing reliance on chemicals is also a focus of research aimed at protecting market access for log and timber exports. New funding from industry and government, recently won by Stakeholders in Methyl Bromide Reduction (STIMBR) via the Primary Growth Partnership, has enabled more research to be initiated in this important area. Scion will be concentrating largely on finding alternatives to methyl bromide treatment for log and sawn timber exports, and on ways of using fumigants safely. We also have a strong research programme to support the industry's use of herbicides under Forest Stewardship Council certification standards (see page 20).

DR BRIAN RICHARDSON
General Manager Forest Science

Scion also works closely with the rural fire sector to provide the support and tools they need to manage fire risks in the landscape. Knowledge from this programme is important as the costs associated with wildfires grow and the risks increase with a changing climate.

Creating new solutions for forest protection problems requires the integration of many science disciplines. A deliberate approach to achieving this integration, using staff across Scion teams and also from collaborating organisations, is a strong theme in our new research programmes. As forests the world over face new and emerging risks, it is important that Scion uses the best resources and skills available to ensure continued protection of New Zealand's natural resources.

> "Needle diseases of radiata pine and Douglas-fir are seen as the highest priority forest health issue in New Zealand's commercial plantations."



Biosecurity Research Plan 2011-16

Forest biosecurity and biosecurity research is a high priority for government and forest industry stakeholders. It is highlighted as an important outcome for Scion in its Statement of Core Purpose. Following is a summary of the Biosecurity Research Plan completed in 2011 to address stakeholder priorities.

Statement of Core Purpose

Scion's purpose is to drive innovation and growth in New Zealand's forestry, wood product and wood-derived material and other biomaterial sectors, to create economic value and contribute to beneficial environmental and social outcomes for New Zealand.

Three of the four outcomes aligned to this purpose clearly encompass biosecurity research. The Scope of Operation states that Scion is the lead Crown Research Institute for forest biosecurity and risk management and mitigation.

Scion's strategy requires us to work with stakeholders to reduce the threat and costs associated with biosecurity risks and to ensure phytosanitary barriers do not impede export market access for wood products.

Stakeholder priorities

Forest biosecurity research is a high priority for government via the Ministry of Agriculture and Forestry (MAF), forest growers and exporters, and for Scion. Key stakeholders that significantly co-fund forest biosecurity research want the majority of funding to target radiata pine issues with a secondary focus on Douglas-fir.

A survey of major stakeholders in 2010 identified the following research priorities:

- Reduce risk from new pests.
- Protect and enhance radiata pine productivity with a focus on overcoming needle diseases.
- Protect and enhance alternative species productivity.
- Protect non-commercial forests (indigenous and urban).
- Protect market access and freedom-to-operate.

SCION'S RESPONSE

Research priorities (2011-2016)

Scion's response to stakeholder feedback focuses on the following research priorities. Development of the associated research programmes will be achieved with governance groups that include primary end-users (noted in brackets).

- Exclude new pests from New Zealand by supporting the Forest Owners' Association/MAF Government-Industry Agreement process and by undertaking pest risk analysis, blocking pathways, improving surveillance, and through effective eradication methods (MAF, Forest Biosecurity Committee, Better Border Biosecurity).
- Reduce impact of insect pests and disease on radiata pine, with a focus on needle diseases, e.g. enhance genetic resistance, biological control using endophytes or viruses, chemical control, modified silviculture, or other novel approaches (Forest Biosecurity Committee).
- Prioritise non-radiata commercial forest pest problems and secure funding to undertake research to reduce their impact (Farm Forestry Association, Forest Biosecurity Committee, MAF).
- Work with indigenous and urban forest stakeholders to reduce the impacts of nationally significant pest problems, e.g. novel approaches to overcoming Dutch elm disease or kauri phytophthora (MAF, Councils, Department of Conservation).
- Enhance market access and reduce phytosanitary risks by developing cost effective quarantine treatments, by verifying secure pathways, and underpinning environmental certification processes (Forest Biosecurity Committee, Stakeholders in Methyl Bromide Reduction (STIMBR), MAF).

Funding for biosecurity research is provided from the following Ministry of Science and Innovation programmes: Better Border Biosecurity Outcome-based Investment; Biosecurity, Protection and Risk Management of NZ Forests; Protecting NZ's environment from Pesticide Exposure (via Lincoln Ventures); Undermining Weeds (via AgResearch); and Beating Weeds (via Landcare Research). Significant additional funding was received from the Forest Owners' Association (through the Forest Biosecurity Committee), Ministry of Agriculture and Forestry, Future Forests Research Ltd, STIMBR PGP, United States Forest Service, Radiata Pine Breeding Company, and the Dothistroma Control Committee. From July 1 2010, a number of the MSI programmes were transitioned to Crown Research Institute Core Purpose Funding (AgResearch and Scion).

Excluding new pests

Exclude new pests from New Zealand by undertaking pest risk analysis, blocking pathways, improving surveillance, and through effective eradication methods.

AERIAL SPRAYING RESEARCH KEEPS INDUSTRY ON TARGET

New Zealand's success at eradicating a number of insect pests has been made possible by the use of aerial spraying.

Aerial application of pesticides and herbicides is crucial for the management of forest pests in New Zealand. Mindful of public concerns about aerial spraying, Scion and the forest industry take seriously the obligation to distribute chemicals as safely and effectively as possible. This focus has kept the forest industry at the leading edge of aerial spray technology in New Zealand's primary sector.

Scion's General Manager of Forest Science, Dr Brian Richardson, is internationally recognised for his work in aerial application. He brings 30 years of experience to this important and often controversial field.

"We have never stopped looking for ways to improve the cost-effectiveness and accuracy of aerial spray operations," he says. "Managing the risks around spray drift has been a strong driver of our research programme, and we have achieved significant results by working in collaboration with the US Forest Service and Canadian Forest Service."

This collaboration has given rise to computer models that can simulate aerial spraying and guide operational decisions, including managing risks associated with spray drift. Linked to geographic information system software, the model produces maps that depict the result of the operation for various scenarios, and enables managers to plan operations for maximum effect and minimum risk.

"Spray models have been used extensively by Scion in pest eradication programmes in New Zealand to guide operational decisions," Brian explains. "Over the past year, Scion has made substantial improvements to the various models available for decision support."

In 2011, Scion's expertise in aerial spraying was applied in the horticultural industry to assist in control operations for *Pseudomonas syringae pv. actinidiae* (Psa). Scion has also invested time in running workshops for the forest industry to up-skill managers in reducing risks from spray drift.

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"Over the past year, Scion has made substantial improvements to the various models available for decision support."

Spray model upgrades

A six-year research collaborative research programme between Scion and Lincoln Ventures Ltd, funded by the Ministry of Science and Innovation (MSI), is providing information that will greatly improve the accuracy and usability of spray models for targeting forest pests.

An integral part of improving the AGDISP modelling system involves understanding the movement of spray within forest canopies. Scion is applying expertise in tree canopy modelling and aerial spraying to better understand these dynamics.

This research and development will ultimately benefit growers and operators who must ensure that day-to-day spraying events meet requirements for optimising efficacy and avoiding drift. By reducing losses to the ground (often 20-70% for tree and vine crop spraying) and from droplet and vapour drift (often 1 – 12%), applicators will be able to use less chemical and avoid adverse environmental exposure to pesticides.

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New calibration protocols for pest eradication

The use of aircraft to apply pesticides has been a key factor in successful eradication campaigns in New Zealand. Using actual data from successful campaigns, Scion has developed new protocols for aircraft calibration that improve the chance of stopping unwanted organisms in their tracks.

The calibration process ensures that the specified pesticide dose is efficiently distributed across the target area at minimum cost. When material is released from an aircraft, it doesn't land with a perfectly uniform spread. This natural variation causes some degree of overdosing and underdosing on small sample areas within the target zone. Underdosing is a particular concern for a pest eradication operation where survivors could re-establish the population.

A new modelling approach proposed by Scion for aircraft calibration allows a more accurate understanding of the spray deposit variation likely to result from different operational specifications. With this knowledge it is possible to understand the trade-offs between operational cost, practical considerations (such as how fast to fly and the distance between flight lines), and the probability that all pests in the target zone receive a lethal dose.

The new calibration protocol has been published in a peer reviewed, international science journal and has been presented to MAF at a workshop. It is available for future incursion responses. Scion has created a publicly available software tool that can assist trained users to determine their calibration requirements for standard operations (http://webapps.scionresearch.com/SwathCalibration). Scion also offers a calibration service for those who require technical support.

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AERIAL APPLICATION RESEARCH
Scion's aim: To improve efficacy and reduce risk and costs associated with aerial spray operations.

THE PATH LESS TRAVELLED

Reducing global movement of invasive pests

For every forest pest that arrives in New Zealand, there is a pathway that brings it here. Apart from a few organisms that have blown in from Australia, the pathway travelled by most invasive pests is not a natural one. They usually arrive as stowaways on imported goods or passenger baggage. Scion is a major participant in national and global efforts to reduce the risks associated with common pathways.

Scion entomologist Dr Eckehard (Ecki) Brockerhoff is leader of research aimed at pathway risk management in the Better Border Biosecurity (B3) collaboration, funded by MSI. This multi-partner, cooperative research programme looks at ways to reduce the entry and establishment of new pests in New Zealand. A big step towards achieving this goal is ensuring that pests never leave their port of origin in the first place or are stopped along the way.

"The more we can encourage others to trade more safely, the better off everyone will be," he says.

Over the past year, Ecki has been heavily involved in global initiates to clean up high-risk pathways. He is working closely with the National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California on a project analysing the costs and benefits of phytosanitary policies. Using wood packaging as a test case, a team of scientists has quantified the effectiveness of current quarantine treatments; the impacts of treatment on the costs of trade; and the risks associated with not doing it.

Now in its third year, this research project is yielding a number of high-impact journal papers. Ecki presented the results to the International Forestry Quarantine Research Group (IFQRG) which provides scientific advice to the International Plant Protection Convention that deals with phytosanitary regulations and policy. Closer to home, he presented to a wood protection research conference in Queenstown, generating high interest among chemical companies and policymakers alike.

Ecki has been a spokesman for a provocative attempt to save the world's forests in his capacity as Deputy Coordinator of the International Union of Forest Research Organisations (IUFRO) Division 7 (Forest Health). A group of 70-plus scientists from 17 countries are asking trade policy makers around the globe to phase out international trade in containerised ornamental plants*. A driving force behind their argument is an unprecedented rise in the number of alien diseases and pests emerging in natural and planted forests worldwide.

"Live plants and soil provide easy pathways for dispersal of tree pests and diseases," Ecki explains. "New Zealand had the foresight to stop most of the trade in live plants, but the market continues unabated in most parts of the world, putting all forests at risk."

Ecki also represents New Zealand on the EU COST-Action programme "Pathway evaluation and pest risk management in transport" or "PERMIT". This collaboration, led by Dr Hugh Evans of Forest Research, UK, includes members from numerous EU and other countries. Their aim is to characterise pathways linked to pest movements and trade patterns and to develop generic risk mitigation measures to reduce pest movements. This year Ecki attended the first science meeting of PERMIT in Belgrade, courtesy of The Royal Society's Mobility Fund.

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PATHWAY RISK MANAGEMENT
Scion's aim: To reduce the risk associated with common pathways for evasive pests.

*The IUFRO proposal is articulated in a document entitled the Montesclaros Declaration, which can be found at: http://www.iufro.org/science/divisions/division-7/70000/publications/montesclaros-declaration/.

Reducing the impact of needle diseases

Increase radiata pine productivity by reducing pest impacts, focusing on cost-effective control of needle diseases.

RESEARCH ON NEEDLE DISEASE GETS GREEN LIGHT

Needle diseases of radiata pine are among the biggest impediments to tree growth in New Zealand's commercial forests. If a pine tree is not green, it does not grow. During 2011 Scion re-structured its biosecurity programme to place new emphasis on growing trees as greenly as possible.

The main needle diseases occurring in radiata pine plantations are dothistroma needle blight and cyclaneusma needle cast. Physiological needle blight is an intermittent disorder, and a condition referred to as red needle cast has also caused defoliation in some parts of the country. Wet weather appears to have sparked an increase in dothistroma needle blight and red needle cast during the past year.

Forest pathologist Dr Rebecca (Beccy) Ganley says the apparent increase in needle diseases isn't confined to New Zealand. Unexpected disease outbreaks are affecting forests in a number of countries and forest health issues have become a global concern.

"This trend may be linked with changes in climate, nutrient shifts, global trade or a raft of other causes. There are no simple explanations and no immediate management solutions," Beccy explains. "On the positive side, New Zealand has the advantage of excellent biosecurity systems and a good track record of overcoming forest health problems."

New Zealand is one of the few countries to have effective systems in place for managing dothistroma needle blight, which is a serious problem in some countries. These systems are based on a large research programme started in the 1960s. There is more work to be done as new diseases emerge and new technologies evolve to overcome them. Scion has initiated a large research programme to give needle diseases the highest priority, drawing on the experience of New Zealand's leading forest pathologists and international collaborators.

"We are exploring every avenue available to overcome needle diseases, from chemical spray and biological control programmes, to genetic resistance and enhancing ecosystem health," Beccy says. "We are part of a network of forest pathologists all over the world who are working to find answers to shared problems."

Tapping international networks

Scion was instrumental in establishing a new COST action focused on dothistroma needle blight during 2011. COST is an intergovernmental framework for European Cooperation in Science and Technology. By participating in this initiative, New Zealand scientists are able to share considerable knowledge about the disease and control options. In return, New Zealand stands to gain from new technology developments as other countries invest heavily in research to overcome the disease in their forests. Scion is also an active member of a separate COST action focused on *Phytophthora*.

The *New Zealand Journal of Forestry Science* published by Scion has a biosecurity focus this year. Volume 41 includes a special supplement that contains papers from the fifth IUFRO Meeting on *Phytophthora* Diseases in Forests and Natural Ecosystems that was held in New Zealand last year. The papers in this supplement capture all aspects of research on *Phytophthora* species from mapping new outbreaks to controlling existing infestations.

Individual papers are available at: http://www.scionresearch.com/nzjfs/volume-41S-Phytophthora-conference-proceedings. A printed copy of the entire volume including the supplement is also available as a one-off purchase.

Building genetic resistance

In any population, some individuals are more disease resistant than others. The Radiata Pine Breeding Company is supporting Scion geneticists to identify which families show greatest resistance to needle diseases. Past success in developing dothistroma resistance in the breeding population is now being extended to other diseases.

Over the past year, Scion assessed the incidence of red needle cast in existing clonal trials. Results showed sufficient variation to indicate the presence of genetic resistance within the population. Scion has also made progress on developing screening systems for needle diseases, which will accelerate the process of identifying resistance in the breeding population. A Massey University PhD student, fully funded by Scion, is examining particular *Dothistroma* genes for clues on what triggers disease resistance or susceptibility. Such knowledge could open up new avenues for dothistroma needle blight control.

GENETIC RESEARCH
Scion's aim: To make new tree stocks available that are resistant to foliage diseases.

Exploring chemical options

The first response to any health disorder, whether it occurs in humans, animals or plants, is usually chemical. In the quest for immediate tools to manage red needle cast, Scion has commenced spray trials this year in affected areas.

While the desired long-term solutions are non-chemical, such as silvicultural practice or genetic resistance, time is needed to identify the best options. The aim of this project is to provide forest growers with an appropriate response to managing red needle cast in the short term.

The Dothistroma Control Committee helped fund an operational aerial spray trial to test the efficacy of applying copper in a mix at 3 litres per hectare instead of the present 5 litres per hectare. Disease levels decreased in all treatments, including the unsprayed control, but importantly disease levels in the sprayed treatments differed from the control by about 7%. Another spray trial to see if the amount of copper applied can be reduced without compromising disease control is starting in December 2011.

CHEMICAL CONTROL RESEARCH
Scion's aim: To provide forest managers with options for controlling needle diseases.

Prevention is better than cure

Scion has a number of research programmes aimed at bolstering the natural defence mechanisms within trees. One method uses fungal endophytes naturally present in tree foliage to prevent diseases by inducing disease resistance. Recent research has identified promising options for using 'friendly' endophytes against cyclaneusma needle cast, diplodia dieback and dothistroma needle blight on radiata pine.

Scientists are now exploring biological control options for red needle cast using endophytes and other beneficial organisms in a collaborative project led by Lincoln University. Scion is also looking at other potential ways of creating healthier and more resilient forests by enhancing soil conditions using mycorrhizae and other microbes.

BIOLOGICAL CONTROL RESEARCH
Scion's aim: To identify long-term options for improving tree health.

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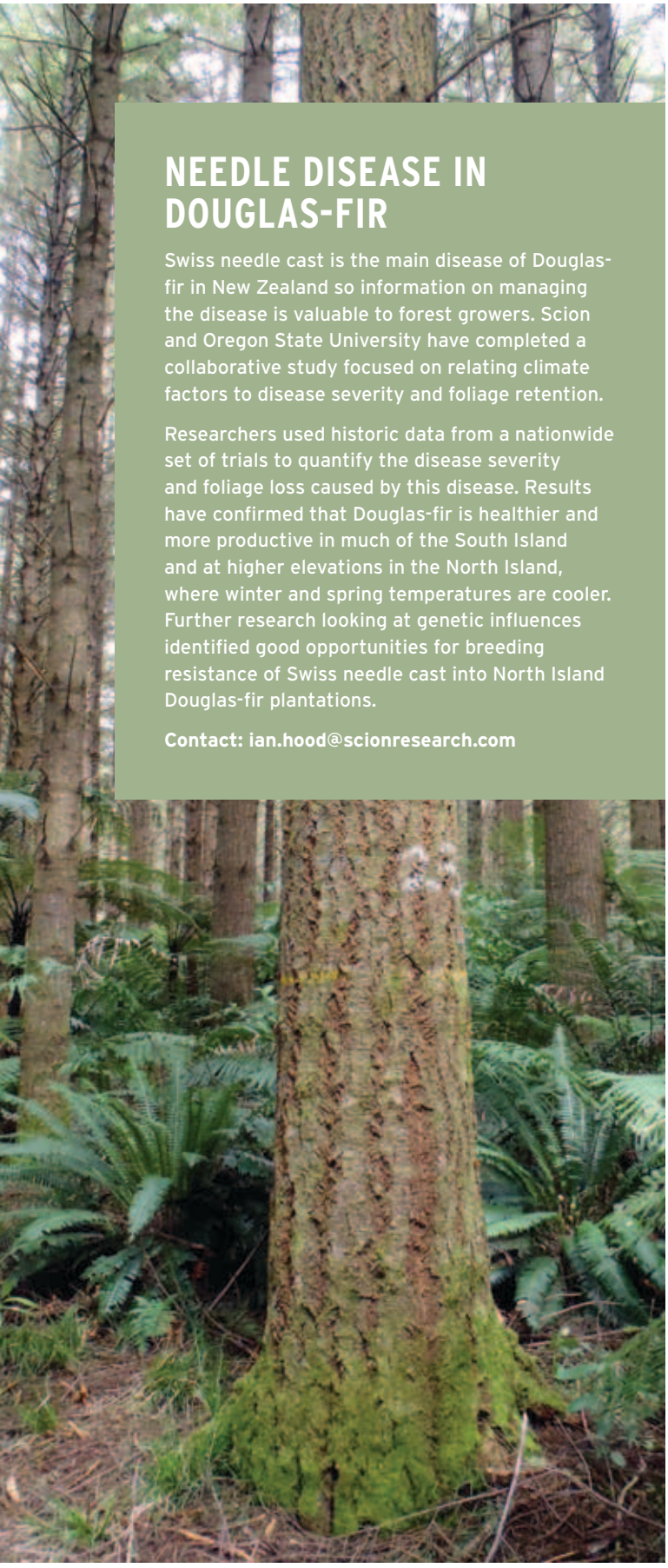

NEEDLE DISEASE IN DOUGLAS-FIR

Swiss needle cast is the main disease of Douglas-fir in New Zealand so information on managing the disease is valuable to forest growers. Scion and Oregon State University have completed a collaborative study focused on relating climate factors to disease severity and foliage retention.

Researchers used historic data from a nationwide set of trials to quantify the disease severity and foliage loss caused by this disease. Results have confirmed that Douglas-fir is healthier and more productive in much of the South Island and at higher elevations in the North Island, where winter and spring temperatures are cooler. Further research looking at genetic influences identified good opportunities for breeding resistance of Swiss needle cast into North Island Douglas-fir plantations.

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INCREASING DIAGNOSTIC CAPABILITY

The ability to detect and diagnose diseases is constantly being enhanced by new technologies.

This year Scion purchased an Eco Real-Time PCR instrument. This machine provides High-Resolution Melting Analysis (HRMA) capability; a method that melts amplified DNA segments over a temperature range and records the melting profiles by detection of fluorescence (incorporated during amplification).

Different DNA sequences, from different organisms, melt with different temperature optima and therefore this method can be used to differentiate pathogens associated with needle diseases.

The investment was made as part of the Innovation Plan written to support MAF's High Risk Site Surveillance programme.

In addition to HRMA, the real-time PCR instrument can be used for quantitative assessment (qPCR) of fungal biomass or spore numbers from environmental samples. A method has been previously developed for quantification of *Dothistroma septosporum* DNA, relative to DNA from pine tissue. This method could be further developed for monitoring biocontrol efficacy, by simultaneously detecting the biocontrol agents in multiplex qPCR assays.

Further diagnostic capability will be established by collaboration with Dr David Cooke (The James Hutton Institute, Scotland) to determine the genetic diversity and possible origins of *Phytophthora kernoviae*. This organism is an important pathogen in United Kingdom forests and has been also been identified in New Zealand.

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Managing non-radiata forest pests

Protect alternative (non-radiata pine) commercial forest species from adverse effects of pests on productivity, wood quality and forest asset value.

Uraba lugens

Paropsis charybdis

BIOLOGICAL CONTROL - Taking nature's approach to pest management

If New Zealand could import a predator to target possums and nothing else, it would save enormous costs and bring welcome relief. Sadly, such specialised predators don't tend to exist in the large animal world, but they do in the miniature world of insects and pathogens. Scion's biological control programme has demonstrated the power of using these specialised relationships for the benefit of forest growers.

Entomologist Dr Toni Withers says the pressure on forest managers to reduce pesticides is driving increased interest in biological control. Although the initial cost is high, the long-term savings of a successful introduction more than make up for it. She cites sirex wood wasp as an early success story.

"Sirex is a serious pest in other countries, costing millions of dollars. In New Zealand sirex is not an issue because we got on top of it with improved silviculture and biological control. Once a pest problem has been averted, it's very easy to overlook the ongoing benefits to the industry," Toni explains.

A more recent and obvious success can be seen all over the Bay of Plenty and central North Island as buddleia bushes are stripped of their leaves. A Chinese leaf weevil (*Cleopus japonicus*) introduced by Scion in 2006 to control the weed looks very promising.

"We are now seeing cases where repeated defoliation is causing the buddleia to actually die, not just slow down," she says. "There are always plenty of weeds to take buddleia's place, but it's good to make such a dramatic impact on any problem species." (See page 20.)

New Zealand forestry companies are constantly looking to reduce pesticide use, not only to save costs, but also to satisfy their commitment to Forest Stewardship Council (FSC) certification. The challenge is that FSC-compliant chemicals are usually more suited to intensive agricultural crops.

"Foresters keep coming back to biological control because it offers a genuine, sustainable alternative to chemicals," Toni says. "We have a high success rate compared with other sectors, so it can be a good option for managing forest pests."

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CURRENT PROJECTS

Wasp released to control gumleaf skeletoniser

Urban pest control was the focus of Scion's latest biological control release - the introduction of a parasitic wasp (*Cotesia urabae*) in January 2011. The Tasmanian wasp was brought in to target gumleaf skeletoniser (*Uraba lugens*), a hairy Australian caterpillar that attacks eucalypts. Biological control is seen as particularly valuable in urban environments because of the huge public pressure against spraying insecticides.

Cotesia urabae

While it is too early to rate the success of this release in Auckland, the wasp has cleared its first hurdle by surviving winter and demonstrating that it can pupate and emerge successfully. Since gumleaf skeletoniser made its first South Island appearance last summer, the Tasman District Council is keen to try the biological control option. Scion is planning a mass release of *Cotesia urabae* in Nelson this summer.

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Targeting pathogens with biological control

Researchers world-wide are looking at new methods for sustainable control of tree diseases. In New Zealand Dutch elm disease is being used by Scion as a test system for biological control methods using viruses.

The aim of Scion's research project is to introduce a virus to attack the pathogen that causes Dutch elm disease (*Ophiostoma novo-ulmi)*. If successful, the virus will reduce the number of dead elms and slow disease spread to other parts of the country.

New Zealand is uniquely situated to use this form of biological control as we currently have a small population of the Dutch elm disease pathogen with low genetic diversity. A genetically uniform pathogen population is expected to be more susceptible to viral biological control agents than a genetically diverse population.

Scion has imported isolates infected with specific viruses into Scion's quarantine facility for rigorous testing. Data obtained from experiments will be used to select the most effective viruses for biological control of this pathogen. This is a collaborative research project between Scion and Forest Research, United Kingdom.

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Industry supports search for eucalypt pest parasites

New Zealand eucalypt growers have been locked in battle with the tortoise beetle *Paropsis charybdis* for many years. Biological control has been the biggest weapon in their arsenal. South Wood Export Limited is supporting a new project to find a larval parasite that will join the battle already being fought by existing egg parasitoids. In 2011 Dr Toni Withers visited Tasmania to begin the process of locating a suitable candidate.

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Paropsis charybdis

BIOLOGICAL CONTROL RESEARCH
Scion's aim: To reduce chemical use and identify long term options for improving tree health.

WHAT HAPPENS WHEN TREES BECOME THE PEST?

Scientists who have focused their career on using chemical sprays to protect trees are now aiming to do the opposite.

Wilding conifers are a major pest in many areas of New Zealand. They are the target of a costly control programme by the Department of Conservation (DOC) which is seeking to protect the country's most scenic high country areas.

In collaboration with DOC, Scion has developed a method for combating wilding conifers in steep terrain using aerial attack. The application of herbicide using a high pressure spray jet has been tested at 14 trials in the South Island. Preliminary results show an 85% kill rate on trees up to six metres in height.

The current approach to high country wilding pine control is to drop tree fellers with chainsaws onto the slopes. The chemical spray method is safer, faster and much cheaper - saving over half the cost of manual operations.

The wilding conifer project is a collaboration between DOC and Scion, under the Landcare Research programme 'Beating Weeds'.

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Protecting market access

Develop and sustain access to high-value markets for logs and wood products by overcoming phytosanitary barriers and maintaining freedom to operate.

KEEPING GREEN EXPORTS CLEAN

Developing sustainable phytosanitary treatments

New Zealand's forestry exports are highly dependent on the use of fumigation treatments to gain market access. Phytosanitary treatment of logs, timber and other forestry-based products is needed to ensure they are free from any pests that could pose a biosecurity threat to importing countries. However the writing is on the wall for methyl bromide, the fumigant on which New Zealand exporters heavily rely.

Scion is supporting a major push by the industry to find alternative biosecurity treatment strategies that are cost effective for producers and acceptable to overseas customers.

A successful application to the Government's Primary Growth Partnership represented a breakthrough for forestry (and horticultural) exporters in 2011. The application, which was led by a group known as Stakeholders in Methyl Bromide Reduction (STIMBR), has attracted enough funding to boost the research effort in this important area.

Scion is a large contributor to this project with research aimed at reducing fumigant release to the atmosphere, developing alternative chemicals and non-fumigant approaches to risk management. Entomology research leader, Dr Steve Pawson, says that although methyl bromide is used safely in New Zealand, environmental and social concerns are mounting against its use.

"There is strong international pressure to eliminate the release of methyl bromide to the atmosphere within the next decade. Our research programme will accelerate progress in areas where reductions are known to be possible, and allow us to explore new methods of protecting exports," he explains.

New Zealand is a relatively high user of methyl bromide because of its large export volumes of unprocessed pine logs and sawn timber, and the local presence of various insect pests of quarantine importance. Understanding the biology and ecology of these insect pests (such as *Arhopalus* and *Hylastes* beetles) is key to reducing the need for fumigation at ports.

" A successful application to the Government's Primary Growth Partnership represented a breakthrough for forestry (and horticultural) exporters in 2011."

Tailoring treatments to fit the risk

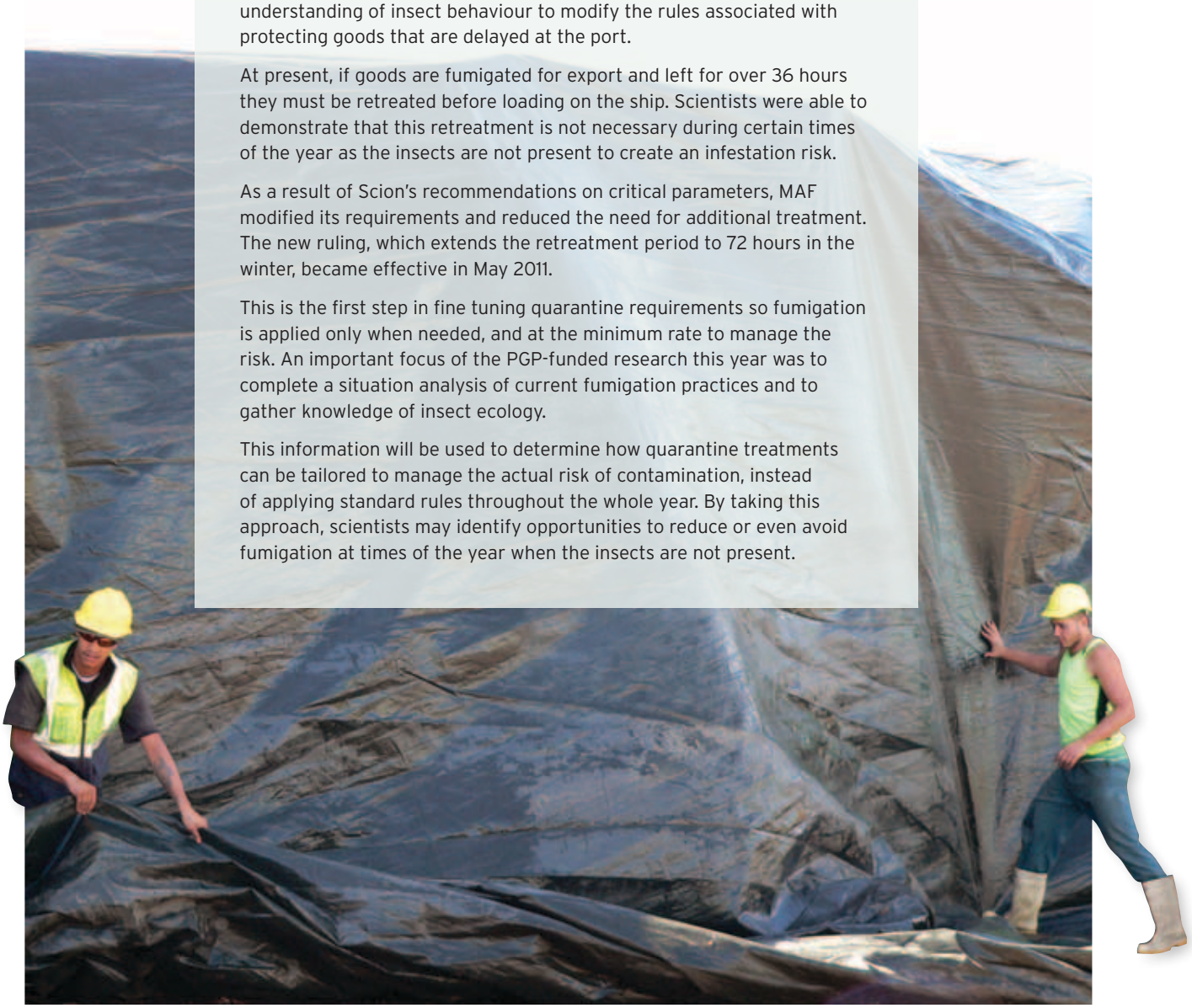
An early outcome of this research programme has used Scion's understanding of insect behaviour to modify the rules associated with protecting goods that are delayed at the port.

At present, if goods are fumigated for export and left for over 36 hours they must be retreated before loading on the ship. Scientists were able to demonstrate that this retreatment is not necessary during certain times of the year as the insects are not present to create an infestation risk.

As a result of Scion's recommendations on critical parameters, MAF modified its requirements and reduced the need for additional treatment. The new ruling, which extends the retreatment period to 72 hours in the winter, became effective in May 2011.

This is the first step in fine tuning quarantine requirements so fumigation is applied only when needed, and at the minimum rate to manage the risk. An important focus of the PGP-funded research this year was to complete a situation analysis of current fumigation practices and to gather knowledge of insect ecology.

This information will be used to determine how quarantine treatments can be tailored to manage the actual risk of contamination, instead of applying standard rules throughout the whole year. By taking this approach, scientists may identify opportunities to reduce or even avoid fumigation at times of the year when the insects are not present.



Developing non-fumigant treatment options

While fumigation providers work hard to find alternative chemicals to methyl bromide, the long-term solution is to avoid fumigants completely. A research collaboration between the University of Canterbury and Scion is developing a method for heat treatment of forest products using electrical currents.

Scion's role over the past year has been to measure the thermal tolerance of key quarantine insects to ensure the required heat levels can be achieved. This research is funded by the STIMBR PGP funding and B3.

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BEATING PEST PLANTS

New Zealand's excellent environment for plant growth is one of its greatest competitive advantages. On the flip side, weeds grow just as well as our economic crops – often better – putting invasive plant species among the most costly pests in the country. With increasing public aversion to herbicide sprays, foresters have learned that weed control must be treated as a science.

A collaborative research programme known as "Undermining Weeds" has provided the coordination, critical mass and science skills necessary to solve the common problems of managing weeds sustainably in New Zealand's forests and pastures. This relatively small but highly effective programme has been identified by MSI as a good example of research that is delivering tangible benefits.

The research providers (AgResearch, Scion, Landcare Research and Plant Protection Chemistry NZ) have worked closely with industry partners to meet the immediate needs of growers. Within the forestry sector these partners include Future Forests Research and the Forest Stewardship Council Cluster Group.

Scion's project leader Dr Mike Watt says that in the commercial forest industry globally, weed control around newly planted trees is recognised as the single most important silvicultural operation to maximise timber production. In New Zealand, it is not just important – it is essential.

"Our research has demonstrated that commercial forestry in New Zealand would be uneconomic without cost effective and environmentally acceptable weed control methods," he explains.

"Weed control during forest establishment ensures tree survival and improves early growth. Studies

show these benefits extend throughout the life of a forestry stand, achieving growth gains of one to four years over stands with no weed control. The key is to achieve these benefits at minimum cost while avoiding negative impacts on the environment."

Promising weed control options developed by Scion include biological control, such as the buddleia weevil which is helping to control one of the most serious forest weeds in the North Island.

Other research focuses on identifying acceptable herbicide options and reducing spray volumes through improved herbicide formulations. Scion also provides training to forest managers on aerial spray operations, with emphasis on reducing risks associated with spray drift.

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CLEOPUS JAPONICUS is a leaf eating weevil released by Scion to help control *Buddleja davidii* (buddleia). Dispersal rates of this weevil are critical to its success within plantations as there is a relatively short window of opportunity following planting until canopy closure for the agent to control buddleia. Dispersal rates have been quantified within trials and are documented in a peer reviewed publication.

Rural fire research

Develop the science and technology needed to protect life and properties.

EVERY YEAR SIGNIFICANT WILDFIRES BREAK OUT IN NEW ZEALAND, CAUSING DAMAGE TO LANDSCAPES AND PROPERTIES.

In summer 2011/12 wildfires have made the headlines yet again, despite it being a wet season across most parts of the country. Although these fires may be small in scale compared with other countries, the costs can be proportionately just as large. When lives are lost, the cost is far too high.

Reducing risks and impacts of forest and rural fires has been a focus of Scion's research for almost 20 years. Senior fire researcher Grant Pearce says that over this period, rural fire management has become increasingly sophisticated in its approach.

"There is a move towards greater professionalism and improved effectiveness of fire fighting operations, which is leading to more uptake of science," he explains.

For every wildfire that breaks out, there is a fire manager reaching straight for fire behaviour field manuals or calculators produced by Scion. Years of data collection from experimental burns and wildfires have gone into building tools that enable managers to make informed decisions in firefighting operations.

"We are also seeing a shift in approach where managers aren't just focused on fire fighting, they're thinking more about reduction and readiness."

Major changes in rural fire management are in the wind, driven by the New Zealand Fire Commission strategy. While the country is currently split into 80 rural fire authorities, the plan is to amalgamate these into larger areas, enabling responsibility and resources to be better shared. Instead of small fire districts being managed by part time staff, larger authorities will be overseen by full-time managers. Grant says this is expected to result in a more strategic approach to risk management.

"We have developed a number of tools and models over recent years that support the four 'Rs' of risk management: reduction, readiness, response and recovery. Fire agencies support our research programmes and are keen to explore new technologies."

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REDUCTION

In New Zealand, as in many areas of the world, human activity is responsible for the vast majority of wildfires. A report completed in 2011 discusses wildfires with a direct human cause, through malicious intent or by accident.

The study highlighted that wildfire arson and malicious lighting of fires are likely to be much more prolific than official statistics suggest. These criminal activities pose a serious risk to New Zealand communities, especially as many such fires are lit close to residential areas. The report highlights various methods employed internationally to reduce the incidence of arson. Options include mapping techniques; investigation and sentencing deterrents; better security; and intervention schemes.

Methods to mitigate the risks of human caused wildfires have been recommended to national agencies and individuals including the National Rural Fire Authority, DOC, New Zealand Police, fire managers and landowners.

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READINESS

Helping New Zealand rural fire agencies to understand changing risks was the focus of two major fire climatology analyses completed during 2011. One study, funded through the New Zealand Fire Service Commission, provided an improved description of current fire climate severity across the country. This study is being used to support the definition of boundaries for proposed enlarged rural fire districts.

The second analysis, conducted as part of a research programme funded by MAF, provides updated estimates of the effects of climate change on future fire danger. Results indicate that fire climate severity is likely to rise significantly in certain regions. A doubling or even trebling of fire danger is possible in some areas as a result of temperature increases, higher wind speeds and lower humidity.

The greatest relative changes are likely in areas where current fire dangers are comparatively low, such as coastal Southland and Wanganui. Significant increases in fire danger are also predicted in the country's current hot spots, namely Gisborne and Christchurch.

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Fire behaviour modelling

Managers have to make fast decisions in wildfire situations, so it is invaluable for them to have information at their fingertips. Over the past year, new fire behaviour models were developed for New Zealand scrub and grassland fuel types. Enhancements include an improved model for predicting rate of fire spread in tussock grasslands using data from tussock fire ecology experiments in Otago. New models have also been developed for native scrub (manuka and kanuka) using data collected from experimental burns in Canterbury.

Scion is incorporating these models into fire behaviour prediction tools used routinely by fire managers to calculate fuel loads and predict fire behaviour.

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A summary of reports arising from these projects can be found on Scion's website:

www.scionresearch.com/fire

Firefighter safety and productivity

Research undertaken by rural fire team leader Richard Parker provides a unique glimpse into the work patterns of people in dangerous occupations. He has developed new ways of measuring workers' activities using wearable video cameras and sensors. This technology enables researchers to gather data about what workers are doing, where they are doing it, and how hard they are working at the time (i.e. heart rate). This research has provided valuable insights into the work of rural fire fighters that will improve productivity and enhance safety.

Monitoring kits have been located with fire crews across the country so they can collect data in real fire situations. Findings from the research to date include data on carbon monoxide exposure in firefighting operations. Results show that carbon monoxide levels do not typically reach dangerous levels in normal operating conditions. However, exposure levels increase significantly for crews working with fire pumps, or in enclosed spaces.

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RECOVERY

To learn from past experience, it is important to document lessons from New Zealand wildfires. The review process has contributed to increased understanding of the factors affecting community resilience and recovery following wildfire events. Findings from the 2004 Mount Somers wildfire and other New Zealand case studies were presented to a range of groups interested in rural fire and natural hazard management during the year. These studies highlighted the importance of community networks and relationships, local knowledge, and access to expert knowledge and institutional capacity in helping build adaptive capacity to wildfires. Scion rural fire researchers maintain strong links with the Bushfire Cooperative Research Centre in Australia where studies on community resilience and recovery are highly topical.

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Significant Publications

Anderson, S. A. J., Anderson, W. R., Hollis, J. J., & Botha, E. J. (2011). A simple method for field-based grassland curing assessment. *International Journal of Wildland Fire, 20*(6), 804-811.

Bain, J., Sopow, S. L., & Bulman, L. S. (2012). The Sirex woodwasp in New Zealand: history and current status. In B. Slippers, P. de Groot, & M. J. Wingfield (Eds.), *The Sirex woodwasp and its fungal symbiont: research and management of a worldwide invasive pest* (pp. 167-174). Dordrecht, The Netherlands: Springer.

Beever, R. E., McKenzie, E., Pennycook, S. R., Bellgard, S., Dick, M. A., & Buchanan, P. K. (2011). Phylum Oomycota: water moulds, downy mildews. In D. Gordon (Ed.), *New Zealand Inventory of Biodiversity; 3. Kingdoms Bacteria, Protozoa, Chromista, Plantae, Fungi.* (Chapter 11). Christchurch, New Zealand: Canterbury University Press.

Beggs, J. R., Brockerhoff, E. G., Corley, J. C., Kenis, M., Masciocchi, M., Muller, F., Rome, Q., & Villemant, C. (2011). Ecological effects and management of invasive Vespidae. *BioControl, 56,* 505-526.

Berndt, L. A. (2010). Will competition from *Meteorus pulchricornis* (Wesmael) (Hymenoptera: Braconidae) limit the success of the potential biocontrol agent *Cotesia urabae* Austin & Allen (Hymenoptera: Braconidae)? *Australian Journal of Entomology, 49,* 369-376.

Bourdôt, G. W., Lamoureaux, S. L., Watt, M. S., Manning, L. K., & Kriticos, D. J. (2010). The potential global distribution of the invasive weed *Nassella neesiana* under current and future climates. *Biological Invasions.* doi 10.1007/s10530-010-9905-6.

Bown, H. E., Watt, M. S., Clinton, P. W., & Mason, E. G. (2011). Soil C/N influences carbon flux and partitioning in control and fertilized mini-plots of *Pinus radiata* in New Zealand. *Ciencia Investigacion Agraria, 38*(2), 277-289.

Brockerhoff, E. G., Suckling, D. M., Ecroyd, C. E., Wagstaff, S. J., Raabe, M. C., Dowell, R. V., & Wearing, C. H. (2011). Worldwide host plants of the highly polyphagous, invasive *Epiphyas postvittana* (light brown apple moth). *Journal of Economic Entomology, 104*(5), 1514-1524.

Brockerhoff, E. G., Jactel, H., Carnus, J.-M., & Pawson, S. (2010). Biodiversity of plantation forests and its relevance for ecosystems functioning. In K. Okabe, & I. Thompson (Eds.), *Proceedings, International Symposium for the Convention on Biological Diversity - The role of biodiversity in the sustainable use of ecosystem goods and services in agro-forestry, fisheries, and forestry.* Tokyo, Japan, April 26-28, 2010.

Falshaw, R., Dick, M., & Ramsfield, T. (Eds.). (2011). *New Zealand Journal of Forestry Science: Proceedings of the fifth International Union of Forest Research Organizations (IUFRO) Working Party S07.02.09 on Phytophthora diseases in forests and natural ecosystems* (Vol. 41S). Rotorua, New Zealand: Scion.

Ganley, R. J., Watt, M. S., Kriticos, D. J., Hopkins, A. J. M., & Manning, L. K. (2011). Increased risk of pitch canker to New Zealand and Australia under climate change. *Australasian Plant Pathology, 40*(3), 228-237.

Grace, J. C., Richardson, B., Gous, S., Thistle, H. W., & Teske, M. E. (2011). Evaluation of the AGDISP canopy model. Paper presented at the *American Society of Agricultural and Biological Engineers Annual International Meeting 2011, 4,* 2798-2810.

Haack, R. A., & Brockerhoff, E. G. (2011). ISPM No. 15 and the incidence of wood pests: recent findings, policy changes, and current knowledge gaps. *Proceedings of the International Research Group on Wood Protection, IRG 42,* Queenstown, New Zealand, 9-12 May 2011.

Hart, M., & Langer, E. R. (2011). *Mitigating the risk of human caused wildfires: literature review and stakeholder study.* (Fire Technology Transfer Note No. 42). Christchurch, New Zealand: Scion.

Hide, S., Tappin, D., & Langer, E. R. (2011). *What is the general public's perception of rural fire danger communications?* (Fire Technology Transfer Note No. 41). Christchurch, New Zealand: Scion.

Hide, S. A., Tappin, D. C., Langer, E. R., & Anderson, S. A. J. (2010). *Assessment of the general public's perception of rural fire danger communications.* (Contract Report No. 18088). Christchurch, New Zealand: Scion.

Hobbs, J. F. F., Miller, E., & Cashmore, P. (2011). Whangaparaoa Dunes and Whanarua Bay Scenic Reserve field trip. *Rotorua Botanical Society Newsletter*, 56, 9-21.

Hood, I. A., Garrett, L. G., Gardner, J. F., & Pearce, S. H. (2011). Decay fungi in decomposing post-harvest *Pinus radiata* root and branch debris. *New Zealand Plant Protection, 64,* 188-194.

Hopkins, A. J. M., Dick, M. A., Carlson, C. A., & Crane, P. E. (2011). Early investigations into the infection courts used by *Neonectria fuckeliana* to enter *Pinus radiata* stems. *European Journal of Plant Pathology.* doi:10.1007/s10658-011-9899-7.

Hopkins, A. J. M., Todoroki, C. L., & Pont, D. (2011). Assessment of the effect of Nectria flute canker on wood quality within mature *Pinus radiata* using multiple methods. *European Journal of Forest Research,* 1-7. doi 10.1007/s10342-011-0522-4.

Iturritxa, E., Ganley, R. J., Wright, J., Heppe, E., Steenkamp, E. T., Gordon, T. R., & Wingfield, M. J. (2011). A genetically homogenous population of *Fusarium circinatum* causes pitch canker of *Pinus radiata* in the Basque Country, Spain. *Fungal Biology.* doi:10.1016/j.funbio.2010.12.014.

Kimberley, M. O., Hood, I. A., & Knowles, R. L. (2011). Impact of Swiss needle-cast on Douglas-fir. *Phytopathology, 101,* 583-593.

Kirschbaum, M. U. F., & Watt, M. S. (2011). Use of a process-based model to describe spatial variation in *Pinus radiata* productivity in New Zealand. *Forest Ecology and Management, 262,* 1008-1019.

Kriticos, D. J., Watt, M. S., Potter, K. J. B., Manning, L. K., Alexander, N. S., & Tallent-Halsell, N. (2011). Managing invasive weeds under climate change: considering the current and potential future distribution of *Buddleja davidii. Weed Research, 51,* 85-96.

Liebhold, A. M., Brockerhoff, E. G., Garrett, L. J., Parke, J. L., & Britton, K. O. (in press). Live plant imports: the major pathway for forest insect and pathogen invasions of the U.S. *Frontiers in Ecology and Environment.*

Mansfield, S., Murray, T. J., & Withers, T. M. (2011). Will the accidental introduction of *Neopolycystus insectifurax* improve biological control of the eucalyptus tortoise beetle, *Paropsis charybdis*, in New Zealand? *Biological Control, 56,* 30-35.

Miller, E. (2011). National Forestry Herbarium – end of an era. *Rotorua Botanical Society Newsletter, 56*, 5-6.

Miller, E. (2011). Omaio beach and cliff plant species. *Rotorua Botanical Society Newsletter, 56*, 52-59.

Murray, T.J., Withers, T.M. (2011). Spread of *Dicranosterna semipunctata* (Col.: Chrysomelidae) in New Zealand and potential for control by intentionally introduced and invasive parasitoids. *Biological Control,* 59, 234-238.

Newnham, G. J., Verbesselt, J., Grant, I. F., & Anderson, S. A. J. (2011). Relative greenness index for assessing curing of grassland fuel. *Remote Sensing of Environment, 115*(6), 1456-1463.

Nicholas, I., & Watt, M. S. (2011). The three potentially most useful exotic forest species for south eastern North Island marginal hill country. *New Zealand Journal of Forestry, 56*(1), 15-19.

Parker, R., Vitalis, A., Moore, D., Ashby, L., Tappin, D., Hide, S., & Baillie, B. (2010). Measuring dangerous work, tree felling and rural firefighting. In *Proceedings, New Zealand Ergonomics Society 16th Conference*, 18-19 November 2010, Nelson.

Pawson, S. M., Brockerhoff, E. G., Watt, M. S., & Didham, R. K. (2011). Maximising biodiversity in plantation forests: insights from long-term changes in clearfell-sensitive beetles in a *Pinus radiata* plantation. *Biological Conservation, 144*, 2842-2850.

Ramsfield, T., & Richardson, B. (2010). IUFRO International Forest Biosecurity Conference 16 - 20 March 2009, Rotorua, New Zealand. *New Zealand Journal of Forestry Science, 40,* 91-92.

Renwick, R., & Pearce, G. (2011). *Fire behaviour case study: Waiomu, 28 January 2008.* (Fire Technology Transfer Note No. 40). Christchurch, New Zealand: Scion.

Richardson, B., & Kimberley, M. O. (2010). Lessons learned from monitoring the effectiveness of the asian gypsy moth aerial spraying eradication program. *Applied Engineering in Agriculture, 26(3),* 355-361.

Richardson, B., Kimberley, M. O., & Gous, S. F. (2011). Aircraft calibration for application of solid baits for pest eradication operations. Paper presented at the *American Society of Agricultural and Biological Engineers Annual International Meeting 2011, 4,* 2818-2842.

Richardson, B., Kimberley, M. O., & Gous, S. F. (2011). Aircraft calibration for pest eradication operations using pesticides formulated as solid baits. *Transactions of the ASABE, 54*(4), 1245-1254.

Rolando, C. A., Gous, S. F., Berndt, L. A., Bulman, L. S., & Carlson, C. A. (2011). Stem injection of a systemic insecticide to control *Uraba lugens* on urban *Lophostemon confertus* trees. *Pest Management Science, 67*(9), 1062-1068.

Rolando, C. A., Gous, S. F., & Watt, M. S. (2011). Preliminary screening of herbicide mixes for the control of five major weed species on certified *Pinus radiata* plantations in New Zealand. *New Zealand Journal of Forestry Science, 41,* 165-175.

Rolando, C. A., Watt, M. S., & Zabkiewicz, J. J. (2011). The potential cost of environmental certification to vegetation management in plantation forests: A New Zealand case study. *Canadian Journal of Forest Research, 41,* 986-993.

Silk, P., Sweeney, J. D., Wu, J., Sopow, S L., Mayo, P., & MaGee, D. (2011). Contact pheromones identified for two longhorned beetles (*Coleoptera: Cerambycidae*) *Tetropium fuscum* and *T. cinnamopterum* in the Subfamily Spondylidinae. *Environmental Entomology,* 40(3), 714-726.

Stevens, P., Bulman, L. S., & Dyck, W. J. (2011). Forestry biosecurity surveillance in New Zealand. *Surveillance, 38(2),* 44-48.

Teske, M.E., Thistle, H.W., Schou, W.C., Miller, P.C.H., Strager, J.M., Richardson, B., Butler Ellis, M.C., Barry, J.W., Twardus, D.B. & Thompson, D.G. (2011). A review of computer models for pesticide depositon and prediction. *Transactions of the American Society of Agricultural and Biological Engineers,* 54(3), 789-801.

Thompson, I. D., Okabe, K., Tylianakis, J. M., Kumar, P., Brockerhoff, E. G., Schellhorn, N., Parrotta, J. A., & Nasi, R. (2011). The role of forest biodiversity in delivery of ecosystem goods and services: translating science into policy. *BioScience,* 61(12) 972-981.

Wakelin, H. M., Anderson, S. A. J., Spearpoint, M. J., & Cochrane, C. H. (2010). Ignition thresholds for grassland fuels and management implications. In *Proceedings of the 3rd Fire Behavior and Fuels Conference, "Beyond Fire Behavior and Fuels: Learning from the Past to Help Guide Us in the Future"*, 25-29 October 2010, Spokane, Washington, USA & Birmingham, AL, USA: International Association of Wildland Fire.

Walbert, K., Ramsfield, T. D., Ridgway, H. J., & Jones, E. E. (2010). Ectomycorrhiza of *Pinus radiata* (D. Don 1836) in New Zealand – an above- and below ground assessment. *Australasian Mycologist, 29*, 7-16.

Watson, M. C., Watt, M. S., Withers, T. M., Kimberley, M. O., & Rolando, C. A. (2011). Potential for *Cleopus japonicus* to control the weed *Buddleja davidii* in plantation forests in New Zealand. *Forest Ecology and Management, 261*, 78-83.

Watson, M. C., Withers, T. M., & Heaphy, M. (2011). *Cleopus japonicus*: releases and distribution of the buddleia biological control agent in New Zealand. *New Zealand Plant Protection, 64,* 155-159.

Watt, M. S., Bloomberg, M., & Finch-Savage, W. E. (2011). Development of a hydrothermal time model that accurately characterises how thermo-inhibition regulates seed germination. *Plant Cell and Environment, 34*, 870-876.

Watt, M. S., Bulman, L. S., & Palmer, D. J. (2011). The economic cost of Dothistroma needle blight to the New Zealand forest industry. *New Zealand Journal of Forestry, 56*(1), 20-22.

Watt, M. S., Ganley, R. J., Kriticos, D. J., & Manning, L. K. (2011). Dothistroma needle blight and pitch canker: the current and future potential distribution of two important diseases of *Pinus* species. *Canadian journal of Forest Research, 41*, 412-424.

Watt, M. S., Kriticos, D.J., Lamoureaux, S., & Bourdôt, G. (2011). Climate change and the potential global distribution of *Nassella trichotoma*. *Weed Science, 59*, 538-545.

Watt, M. S., Palmer, D. J., & Bulman, L. S. (2011). Predicting the severity of Dothistroma on *Pinus radiata* under current climate in New Zealand. *Forest Ecology and Management, 261*, 1792-1798.

Watt, M. S., Palmer, D. J., & Bulman, L. S. (2011). Predicting the severity of Dothistroma needle blight on *Pinus radiata* under future climate in New Zealand. *New Zealand Journal of Forestry Science, 41*, 207-215.

Watt, M. S., Palmer, D. J., & Höck, B. K. (2011). Spatial description of potential areas suitable for afforestation within New Zealand and quantification of their productivity under *Pinus radiata*. *New Zealand Journal of Forestry Science*, *41*, 115-129.

Watt, M. S., Stone, J. K., Hood, I. A., & Manning, L.K. (2011). Using a climate niche model to predict the direct and indirect impacts of climate change on the distribution of Douglas-fir in New Zealand. *Global Change Biology, 17*, 3608-3619.

Watt, M. S., Stone, J. K., Hood, I. A., & Palmer, D. J. (2010). Predicting the severity of Swiss needle cast on Douglas-fir under current and future climate in New Zealand. *Forest Ecology and Management, 260*, 2232-2240.

Watt, P. J., & Watt, M. S. (2011). Applying satellite imagery for forest planning. *New Zealand Journal of Forestry, 56*(1), 23-25.

Withers, T. M., Phillips, L. D., Bates, T. E. M., & Ganley, R. J. (2011). Hybridisation between populations of *Enoggera nassaui* in New Zealand. *New Zealand Plant Protection, 64,* 44-48.

Withers, T. M., Potter, K. J. B., Berndt, L. A., Forgie, S. A., Paynter, Q. E., & Kriticos, D. J. (2010). Risk posed by the invasive defoliator *Uraba lugens* to New Zealand native flora. *Agricultural and Forest Entomology*, *13*, 99-110.

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Spore head of a sap-staining *Leptographium* species.

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