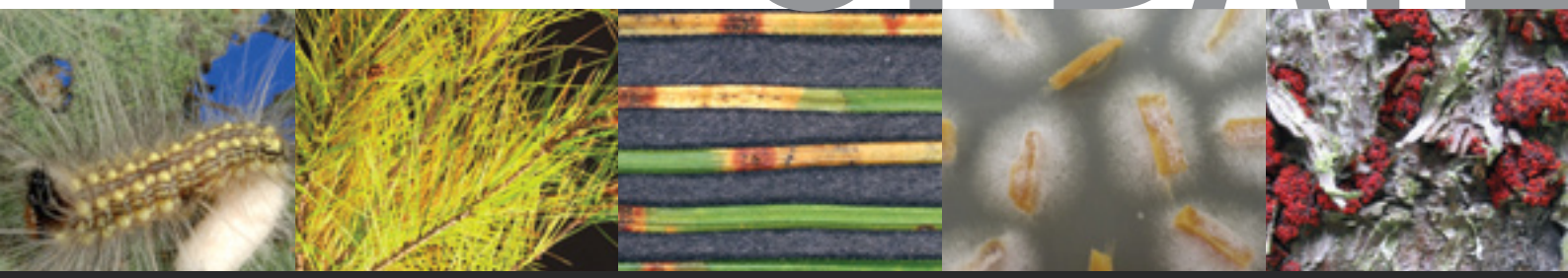
RESEARCH UPDATE



A Summary Of Research 2009

Forest Biosecurity Research Council

Members of the Forest Biosecurity Research Council:

NZ Forest Owners' Association Inc., Scion, Bio-Protection, MAF Biosecurity New Zealand, Forest Health Research Collaborative, Radiata Pine Breeding Company Ltd.

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FOUNDATION FOR RESEARCH SCIENCE & TECHNOLOGY
Te Pāpapa Rangahau Pūtaiao

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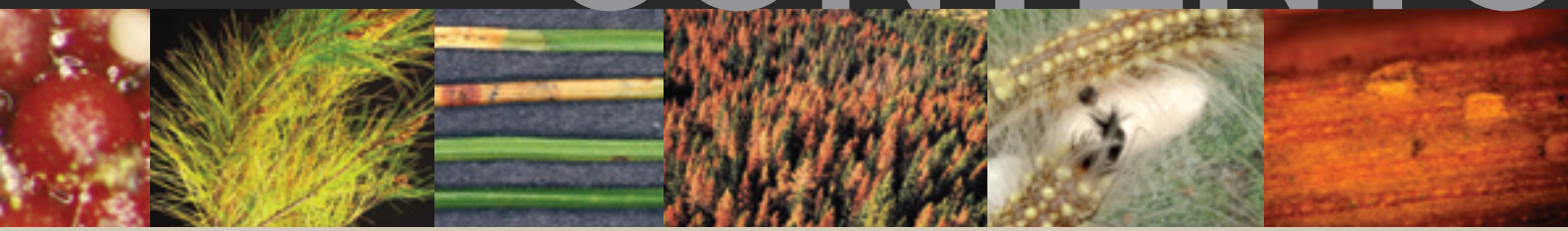


ISSN 1177-1747

FOREWORD

DAVID BALFOUR (CHAIRMAN)

Earlier this year I had the pleasure of giving an opening address at the IUFRO International Forest Biosecurity Conference in Rotorua. The size and the nature of this gathering highlighted the importance of forest biosecurity on a global scale.

As forest owners, we tend to be most concerned about the pests and diseases that impact our own plantations. However, it doesn't hurt to be reminded that maintaining the health of our forest resource is highly dependent on the national biosecurity systems that protect it and the large body of science that underpins these systems.

An important theme of the conference focused on improving the interface between science, policy and forest management – a relationship that lies at the heart of the Forest Biosecurity Research Council (FBRC). For any biosecurity system to be effective these three elements must work together; yet they often come into conflict due to fundamental differences in how they tackle problems.

If the forest manager has a problem, he wants to fix it as quickly and cheaply as possible. The policy maker has similar imperatives, but usually needs to weigh his options against numerous other conflicting needs. The questions asked by the manager and policy maker are: what are we dealing with and how can we tackle it? The scientist, on the other hand, is driven by the "why?" questions, which often take a long time to answer.

Finding balance between the what, how and why questions

"Global forest biosecurity issues serve as a timely reminder of why this kind of research is so important."

is a core focus of the FBRC. As a group of representatives from science, forestry and policy we are living proof of how this partnership can function for the benefit of all parties. Feedback from conference delegates suggests that, here in New Zealand, we are well ahead of other countries in this respect – possibly due to the small size of our population, but mostly because of the high priority we place on protecting our natural resources.

The benefits of our partnership are highlighted throughout this report, where we demonstrate the practical solutions arising from targeted research programmes. These solutions include: silvicultural remedies for Nectria flute canker (page 5); improved chemical control options for Dothistroma (page 11); a new agent for the biological control of gumleaf skeletoniser (page 9); and research on the use of beneficial endophytes to enhance the disease resistance of radiata pine (page 12).

Global forest biosecurity issues, as highlighted by the conference, serve as a timely reminder of why this kind of research is so important. All forests face growing risks from pests and disease due to changing climate and increasing trade. These risks could have enormous implications for biosecurity and our freedom to export. They remind us why it is necessary to maintain a healthy science capability to help us protect this freedom. The FBRC is looking for ways to ensure that funding keeps pace with inflation to sustain this capability.

I would like to thank the FBRC members who work long and hard in the interests of the sector. I particularly acknowledge our administrator, Don Hammond, who was an articulate champion of our interests at the conference. The issues of biosecurity are often complex and daunting. I congratulate our members for their willingness to tackle these issues head-on and come up with meaningful results that benefit us all.

FBRC PROJECTS

This section of the report summarises projects co-funded by the FBRC.
A brief summary of the project titles and funding contributors is given below.
The contents of this report cover the 2009 calendar year.

ALLOCATION OF EFFORT SPENT ON EACH OF THE FBRC PROJECTS ($000)

Project	FBRC	FRST	Industry	FIDA*	Total
Understanding Nectria	105	164	30	98	397
Needle cast disease	20	27			47
Control of Glumleaf Skeletoniser	10		83		93
Rapid identification	45	73			118
Induced resistance using endophytes		125		30	155
Reducing pesticide sprays			80	75	155
Ectomycorrhizal fungi	30	26	6	15	77
Risk from new bark beetles	25	35			60
Colonisation of windthrown trees	10	85	10		105
Microbial control of pests and diseases	50	330	115	16	511
Total	**295**	**865**	**324**	**234**	**1718**

* Forest Industries Development Agenda

GOVERNMENT SUPPORT FOR FOREST BIOSECURITY RESEARCH

The industry-funded FBRC projects described in this report are underpinned by substantial Government support from the Foundation for Research, Science and Technology (FRST). This additional funding provides benefit to the forest industry through comprehensive research programmes, the largest of which is maintained by Scion.

The Scion Forest Protection programme covers the entire risk management spectrum including:

- Excluding new pests
- Managing existing pests
- Services and facilities
- Rural fire research

For a full summary of these programmes, see the Scion Forest Biosecurity and Protection Annual Science Report 2009 – available through Scion.

Contact: rose.o'brien@scionresearch.com for a copy.

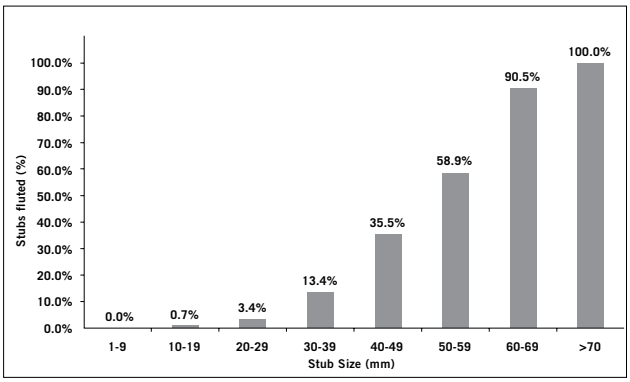
Major advances were made in understanding and managing Nectria flute canker in 2009.

Managing Nectria Flute Canker

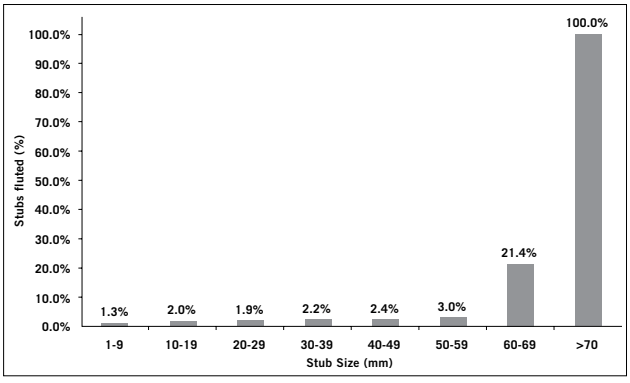
Scion has demonstrated how forest managers can reduce the impact of *Neonectria fuckeliana* through silviculture. Studies show that pruning or inoculation with *N. fuckeliana* in winter resulted in a higher incidence of fluting than pruning or inoculation in summer. Fluting was also found to be positively related to stub size. Nearly all the flutes that have persisted were associated with stubs larger than 60 mm, the others have disappeared over time (see graphs at right). Six years after pruning, less than 3% of stubs under 60 mm diameter were associated with flutes.

By limiting branch stub size to less than 60 mm and avoiding pruning operations in winter, Nectria flute canker should be almost eliminated. We have received reports that forest companies following such a regime are already recording reduced disease levels.

In order to confirm these observations, research was undertaken to elucidate the effect of pruning and stub size on disease development. We know that Nectria flute canker is associated with *N. fuckeliana*, yet the fungus has been found in unpruned trees with no disease. An experiment was established to further our understanding in the role of pruning stress and the initiation of disease development. We also examined data collected in a series of pruning trials established throughout New Zealand. Records of stem damage, starting in the mid 2000s, were most common in three trials located in Otago/Southland and were absent in trials planted elsewhere. We are now examining those data to determine if stem damage was more common in treatments favouring large branches. If so, the branch size model TreeBLOSSIM will be used to simulate a selection of silviculture regimes and calculate the percentage of branches that exceed 60 mm in diameter. The next step will be to model



Percentage of fluted stubs for all treatments, first lift whorls, in August 2004



Percentage of fluted stubs for all treatments, first lift whorls, in March 2009

disease incidence and thus value loss, to enable foresters to make informed decisions on the best silviculture regime to use to minimise loss from Nectria flute canker.

Contact: lindsay.bulman@scionresearch.com

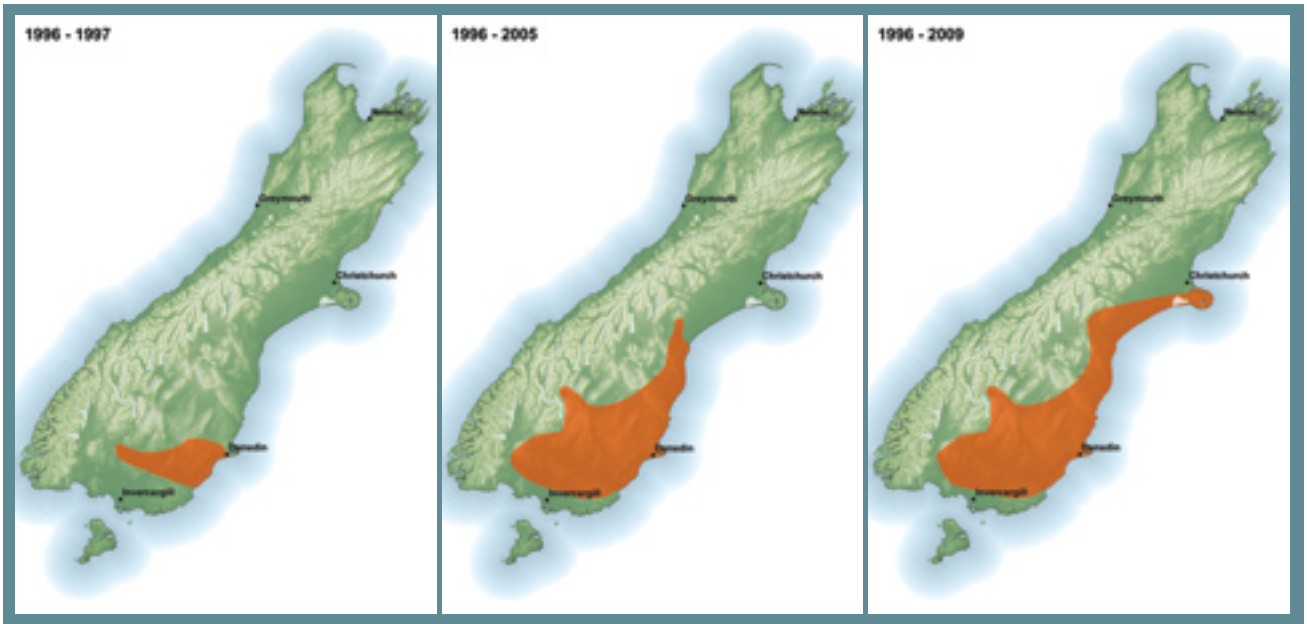
Nectria flute canker spread

Canterbury, Westland, Nelson, and the central North Island, regions well outside the area known to be affected by Nectria flute canker, were surveyed in 2004. After it had been established that *N. fuckeliana* was not present in those regions, targeted surveys to delimit *N. fuckeliana* in Otago and South Canterbury started in 2005. At that time the fungus had been confirmed as far north as Geraldine (see below). In 2007 it was discovered in mid Canterbury on Banks Peninsula. This is still the northernmost find.

The apparent rate of spread during 2006-09 is considerably slower than that seen over earlier periods. We know that moisture is needed for spore release and dispersal. It is likely that the dry climate in Canterbury is not conducive for fungal spread and disease development.

Some intriguing questions have arisen from this work. Other studies have shown that *N. fuckeliana* is present in trees growing in Southland and Otago that were pruned in the 1980s. However, reports from the forest health surveillance scheme indicate that flute canker started in the south during the mid 1990s and results of the delimiting surveys support the idea of a northern expansion of the disease.

We are attempting to resolve the contradiction between distribution and spread of the fungus as determined by surveys and the finding that the fungus is present in trees pruned before the 1990s. Trials have been established to monitor spread within and between stands in Banks Peninsula and other parts of Canterbury. A comprehensive analysis of disease incidence on a regional basis over time is now underway. Dissection of mature affected trees throughout



Known distribution of Nectria flute canker from 1996 to 2009

the known infected area would also provide some useful information on which to determine when and where the fungus was introduced into New Zealand.

The most significant findings from the delimiting surveys to date are that Nectria flute canker has not been found further north than Banks Peninsula, and that its rate of spread through Canterbury is very slow.

Contact: lindsay.bulman@scionresearch.com

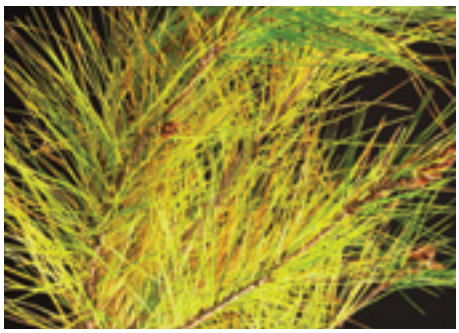
Survey export logs

In November 2009 a survey was undertaken to determine whether log stocks destined for export contained fruitbodies of *N. fuckeliana*. Surveys of logs awaiting export were undertaken at both Port Chalmers and the Port of Bluff. Both log ends and bark-covered sides were examined closely for the presence of fruitbodies of *N. fuckeliana*. The logs examined spanned a range of log classes and included both pruned and unpruned resource from a wide variety of forest companies and forest locations in southern New Zealand.

In total, 44 000 log ends were examined and no living fruitbodies, or evidence of old fruitbodies were found on any logs. Similarly, of the 550 log sides examined, none were found to contain fruitbodies of *N. fuckeliana*. This finding suggests that the risk of spreading disease through log exports is low. A second survey of export logs will be undertaken in early Autumn 2010.

Contact: anna.hopkins@scionresearch.com

Cyclaneusma needle-cast is not as severe as it was 25 years ago.



Aerial surveys to assess the incidence and severity of Cyclaneusma needle-cast were carried out in spring 2005 and 2006 and data collected were compared with those from similar aerial surveys undertaken in 1983-85. The objective was to estimate the economic impact of the disease.

In the forests surveyed from 1983 to 1985 mean disease incidence and severity was 18% and 27%, respectively. Disease levels were lower in 2005 and 2006, where disease incidence and severity averaged 20% and 22%, respectively. The total financial loss attributable to Cyclaneusma needle-cast over the *Pinus radiata* estate aged between 6 and 20 years was estimated to be $38 million per annum. This is considerably lower than estimates, using the same stumpage, of over $60 million per annum that were made based on the 1980s data.

The elimination of highly susceptible genotypes from the *P. radiata* breeding population, and a reduction in susceptible area are thought to be the factors responsible for reduced impact of Cyclaneusma needle-cast. Operational trials to test the feasibility of silvicultural control will be established in 2011, if a suitable site with adequate disease levels can be found.

Attempts to obtain a relationship between disease severity and autumn rainfall at the micro-site level were not successful, although a weak relationship was found with data from the East Cape.

Contact: lindsay.bulman@scionresearch.com

Control options for gumleaf skeletoniser (*Uraba lugens*) are being developed.

Biological control

The gumleaf skeletoniser (*Uraba lugens*) is widespread in the Auckland region. It is now well established in Hamilton in the Waikato, and at Mt Maunganui in the Bay of Plenty, although it does not appear to be causing significant damage in these latter areas as yet. No new locations have been identified for this pest over the past year, and there have been no reports so far of impacts in commercial plantations.

The development of biological control of *U. lugens* is nearing completion. This year Scion completed the host range testing of the parasitoid *Cotesia urabae* and are now analysing and interpreting the data. Although the parasitoid did respond to some of the native non-target caterpillars presented to it in small cages, the attacks were far less than what was found on the target *U. lugens*, and no parasitoid adults were reared from non-target larvae, indicating that these native species are not suitable for the development of this parasitoid.

To better understand what the laboratory results of host range testing might mean when the parasitoid is free in the field, we are working with Dr Geoff Allen at University of Tasmania to conduct field tests in the parasitoid's native range. An honours student, Raylea Parr, has been working on this with Dr Allen. She conducted the same laboratory host range tests we have done here in New Zealand, using an Australian caterpillar (*Nyctemera amica*) that is very closely related to one of the non-target species we tested here (*Nyctemera annulata*). She found that the parasitoid attacked the Australian species in the laboratory test, as was found with the New Zealand species (although attack was unsuccessful in the laboratory for both species). She then studied wild populations of the Australian species, which occur in the same habitat as *U. lugens* and its parasitoid *C. urabae*, and found no evidence that the parasitoid successfully attacks *N. amica* in the field. This work is currently being completed, and will provide supporting evidence for the application to ERMA to release *C. urabae* in New Zealand.

Contact: lisa.berndt@scionresearch.com

Chemical control

In 2004, the FBRC commissioned research on the feasibility of injecting insecticides into the stems of trees. It showed that stem injection had potential as insect control method, particularly for use on specimen trees in public places. This work, funded by MAFBNZ and FRST, continued in a series of trials in the Auckland region to investigate the efficacy of stem injection as a control measure for gumleaf skeletoniser .

The results indicated that injections using an "animal remedy dose gun" were the easiest and most efficient method of applying insecticides. Acephate, an organophosphate, was found to

CONTROL OF URABA

translocate most effectively throughout the species of trees attacked by *U. lugens*, with up to 80% larval mortality recorded in the field at the highest dose tested.

Uraba lugens is a significant urban pest of *Eucalyptus* spp. and *Lophostemon* spp. in the Auckland region. It is considered a human health problem because larvae have urticating hairs that can cause painful dermatitis. Control of Uraba is therefore important, but the main aim of the recent stem injection work was to determine the relationship between insect mortality assessed in the field and mortality assessed using laboratory bioassays. There was a good correlation between field assessments and bioassays. This finding vindicates the use of bioassays to determine the success of spray operations to eradicate lepidopteran pests.

Contact: carol.rolando@scionresearch.com or stefan.gous@scionresearch.com

RAPID IDENTIFICATION

If an exotic pest were to arrive in New Zealand, the faster that it can be identified, the greater the chances of eradication. This is because an incursion response can be mounted while the geographic area infested is small. Scion has developed species-specific diagnostic systems for some high risk forest pathogens that can be used independently. An improvement on these independent systems is a single system that can identify multiple pests. One such technology is a multi-species specific "macroarray".

The goal of this project is to develop a macroarray system for pathogens of *Pinus radiata*. Tod Ramsfield travelled to Canada in October 2009 to work with Dr André Lévesque of Agriculture Canada on the development of this macroarray. Dr Lévesque has developed macroarray systems for pathogens, including *Pythium* and *Phytophthora*, as well as horticultural crops such as cranberry. DNA sequence data from pathogens of *P. radiata* has been analysed and the objective for 2010 is to begin developing the array.

Contact: tod.ramsfield@scionresearch.com

PREDICTING SAPSTAIN IN WINDTHROWN TREES

Scion initiated a project to monitor the rates of deterioration of windthrown trees following storms two weeks apart in the Nelson region in late winter, 2008. The purpose of this study was to provide advice to industry so that better informed log recovery operations may be undertaken.

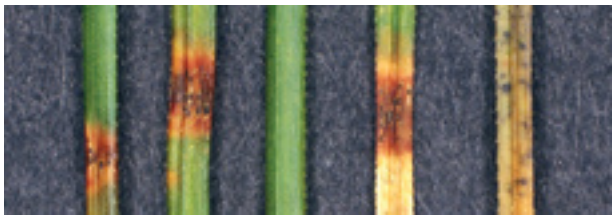
Sapstain, bark beetle attack, and occurrence of decay fungi were first detected at 5-6 months in stems cut at the base (to simulate breakage), and the incidence of all three agents increased thereafter. However, fallen but still partly rooted trees remained sound for up to a year after the storms. Moisture content decreased during the course of the monitoring period, especially in severed stems, and deterioration did not occur until levels fell below 120% (dry weight basis).

While the initial study is now completed, the project has been extended in order to widen the database. Trees are being felled at different times of the year at four new sites in both the North and South Islands in order to compare the rates and nature of deterioration in different seasons and climate regions.

The ultimate aim of this research is to provide reliable guidelines to facilitate effective decision-making during salvage operations in pine plantations following storm damage.

Contact: ian.hood@scionresearch.com or eckehard.brockerhoff@scionresearch.com

REDUCING PESTICIDE SPRAYS ON DOTHISTROMA



Work undertaken over the last three years has shown that cuprous oxide appears to be the most suitable copper fungicide of those on the market. A number of alternative oils and mixes have been eliminated based on physical properties and droplet spectra characteristics.

Research also showed that copper persists on foliage for three months, longer than first thought. There is a weak trend towards increased copper persistence with increased proportion of oil in the mix. However, spray mixes with copper and oil only produced larger droplets than those with copper, oil, and water. It is possible that the negative effects of large droplets with increased proportion of oil might be balanced by increased copper persistence.

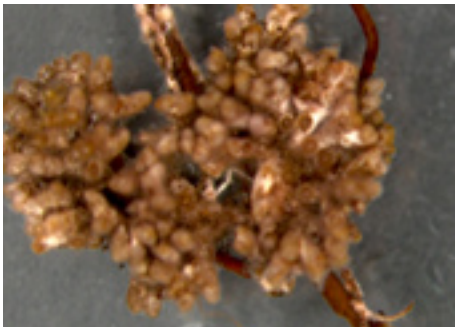
The application of these results and the assumptions made were tested in an operational spray trial established in December 2009. Full results are not yet available, but all four spray mixes tested were applied without mishap and the spray equipment coped with the higher viscosity of the copper and oil only mix.

Although the FBRC did not provide direct funding for this work in 2009, it was responsible for it under the auspices of FIDA.

Contact: stefan.gous@scionresearch.com

ECTOMYCORRHIZAL FUNGI

Ectomycorrhizal (ECM) fungi are an intrinsic part of the rhizosphere and plant nutrition.



These fungi enhance the growth of plantation species and facilitate the establishment of nursery plants in the forest. ECM fungi have been a research focus at Scion in recent years, investigating the role of ECM fungi after establishment in the plantation.

We are currently studying the fungal associates of *Pinus radiata* and *Pseudotsuga menziesii* in several nurseries across the country, covering a range of soil conditions as these are presumed to change ECM communities. We are also determining if there are differences in ECM on planting stock originating from seed, cuttings or root trainers.

Plants have been assessed in the nursery and will be followed up after a year in the forest. Interim results showed that ectomycorrhizal colonisation varied considerably in terms of abundance and diversity between nurseries and plant types.

A new project is looking at the influence of fertiliser and fungicide applications on ECM communities of *P. radiata* and how this, in turn, affects growth of seedlings in the nursery and their establishment and performance in the field.

Contact: katrin.walbert@scionresearch.com

INDUCED RESISTANCE USING ENDOPHYTES

To advance our understanding of induced resistance mechanisms in forests, a research project investigating the effectiveness of non-pathogenic fungal endophytes in *Pinus radiata* was initiated. Fungal endophytes are fungi that live within their host without causing any disease symptoms.

Fungal endophytes from foliage of *P. radiata* trees affected by Cyclaneusma needle-cast and from healthy trees in the same stands were compared. The purpose was to identify any potential beneficial endophytes for future induced resistance research or endophytes that may contribute to, or be involved in, disease expression. A selection of these fungal endophytes was then tested using laboratory-based methods for their effect on the pathogen *Cyclanesuma minus*. Currently, these fungal endophytes are being screened for their ability to provide beneficial functions in their host plants.

Contact: rebecca.ganley@scionresearch.com

RISK FROM NEW BARK BEETLES

Scion undertook a study to estimate the risk of establishment of exotic wood- and bark-boring insects in New Zealand and the potential damages that could result.

Pine beetle damage in Canada

Wood borers and bark beetles are among the most serious forest pests worldwide. International trade in forest products and, in particular, the widespread use of wood packaging materials are significant pathways for the introduction of such borers.

New Zealand already operates high-risk site and forest health surveillance programmes which should enable detection of new invaders. However, a recent external evaluation of New Zealand's Forest Health Surveillance programme, commissioned by the Forest Owner's Association, recommended the implementation of a trap network for detecting wood-boring insects across New Zealand.

Historical records of interceptions and establishments in New Zealand and overseas show that there have been numerous interceptions of borers that pose serious biosecurity risks to New Zealand's forests. Among the more serious invaders are *Dendroctonus valens* which kills pines in China, and *Ips grandicollis* which currently has serious outbreaks in drought affected parts of Australia where it is causing mortality of radiata pine. In New Zealand, relatively few establishments of borers have occurred but cases recorded in other countries demonstrate that the risk is high. Border interceptions and establishments of borers have increased in the last two decades as a result of growing international trade. Phytosanitary measures in New Zealand and internationally (e.g., ISPM 15) have counteracted this to some degree.

Trap-based surveillance programmes for borers have been implemented in various countries (e.g., Australia, USA), and these have been successful. An ongoing programme in the USA that started in 2001 detected one new species per year, on average, over the following five years. Among the detections was one new species attacking pines (and other Pinaceae), *Hylurgops palliatus*. In New Zealand, a similar programme run by MAF-Biosecurity New Zealand was in operation for three years until 2005 (no new species were detected), but it was discontinued because of a lack of funding.

A new trap-based surveillance programme may lead to earlier detection and, therefore, an increased likelihood of successful eradication or other emergency response. Such a programme comes at a cost, so stakeholders must decide whether the risks posed by borers and the benefits of an additional surveillance programme justify this expenditure. If there were no new establishments, costs would exceed the benefits. Conversely, if a trap-based programme led to the early detection and subsequent eradication of a potentially damaging borer, then there could be large net benefits to the industry.

Contact eckehard.brockerhoff@scionresearch.com

New biological control agents are needed to provide the industry with effective and sustainable pest and disease management options.

Pinus radiata seed-coating and root enhancement of cuttings and seedlings with beneficial microbes and natural products

A seed-coating kit for beneficial microbes was developed for use by nurseries and used by the PF Olsen Nursery to treat their 2009/10 *Pinus radiata* seed with ArborGuard™. Other beneficial microbes can be applied to seed using this method.

Nursery trials with seedlings and cuttings in containerised and soil bed systems were established to evaluate isolates of beneficial microbes. Several novel isolates of *Trichoderma* have significantly increased root dry weights (by 50-250%), improved the survival of healthy rooted cuttings and also increased establishment and seedling vigour. We intend to develop these, which will then be made available to the industry.

Contact: robert.hill@lincoln.ac.nz

Armillaria disease forestry trials

The *Armillaria* disease forest plantation trials in the Rotoiti Forest (established in 2007) and the Kaingaroa Forest (established in 2001), were assessed for tree health, mortality and growth in June 2009. At Rotoiti, the ArborGuard™ *Trichoderma*-treatment had the highest health score and the lowest mortality from *Armillaria* disease (less than 5%). At Kaingaroa, tree mortality from *Armillaria* was virtually unchanged from the previous assessment in 2004, when ArborGuard™ reduced mortality by 33% compared with the untreated control. There were no significant differences between treatments for tree height and DBH (diameter at breast height).

Contact: robert.hill@lincoln.ac.nz

Entomopathogenic fungi for biological control

Entomopathogenic fungi are important natural mortality factors in bark beetle populations. To effectively utilise these agents in a bioprotection strategy, cost-effective delivery systems are needed. Some isolates are rhizosphere-competent; delivery of these biological control agents to the seedling root zone of radiata pine via seed coatings would be simple to implement by the forestry industry.

This project assessed the survival of selected *Beauveria* and *Metarhizium* spp. isolates in seed coatings applied to stratified seed and determined the compatibility of *Beauveria bassiana* and *Trichoderma* spp. As the fungi could be co-inoculated onto seeds, compatibility is essential to ensure the biological control agents function effectively.

In general, *B. bassiana* conidia survived better on the seed, irrespective of the coating material and method used, than *M. anisopliae*. Survival of fungal conidia was better in xanthan, methylcellulose and poly-ethylene oxide coatings and spray coating was a superior method of application. Vegetative compatibility of the fungi was demonstrated. Superior seed coating materials that preserve the viability of fungal conidia on seeds have been identified and their ability to deliver microbes into the pine root zone now needs to be confirmed. Compatibility between two (or more) biological control agents is an important selection criterion that must be considered in future development work.

Contact: tracey.nelson@agresearch.co.nz

Biological control of Dothistroma with microorganisms

Around fifty selected beneficial microbes were screened for antagonistic activity against Dothistroma. The best five microbes are being tested in small-scale/field trials *in planta*, for control of Dothistroma disease. This work

involves collaboration between Massey University and Scion.

The Joint Genome Institute in the USA have agreed to sequence the whole genome of *Dothistroma septosporum*. The New Zealand strain is the one being sequenced and analysis of the genome will mainly be carried out at Massey University. It is hoped that the genome will eventually reveal key genes involved in infection and disease progression, and provide targets for new ways to control the disease.

Contact: r.e.bradshaw@massey.ac.nz

Inoculation of tissue cultured *Pinus radiata* with beneficial microbes

Pinus radiata tissue cultures were inoculated with selected beneficial microbes known to have disease and insect control activity, at The Tree Lab. Surviving trees will be screened for enhanced resistance to pests and diseases and for increased growth.

Contact: jenny@thetreelab.co.nz

Bio-protection of *Acacia mangium* with *Trichoderma* in Sarawak, Malaysia

Based on our success in New Zealand forestry bioprotection using *Trichoderma* Dr Robert Hill (of the Bio-Protection Research Centre, Lincoln University), was contracted by Grand Perfect Sdn Bhd and Sarawak Planted Forests Sdn Bhd to develop a new bioprotection system using *Trichoderma* for the Planted Forest Zone in Sarawak, Malaysia.

Trichoderma was isolated in pure culture from a variety of healthy plant species in the Bintulu/Tatau districts. These isolates were evaluated in nursery trials with *Acacia mangium* seedlings at the Samarakan Nursery during 2008 and 2009. The best *Trichoderma* isolates (e.g. from *Hymenocallis littoralis* (illustrated) and species of bamboo, banana, black pepper, sugar cane and red palm) increased *Acacia* seedling growth and vigour and reduced losses from disease without using fungicide sprays. The proportion of seedlings "meeting specification for planting out into the forest" was increased by 40 – 50% using *Trichoderma* inoculation as "standard practice" for production over 30 million *Acacia mangium* seedlings per annum.

Contact: robert.hill@lincoln.ac.nz

Forest Biosecurity Research Council

www.fbrc.org.nz

For more information on FBRC, membership details and science reports.

Representative contacts:

NZ Forest Owners' Association

David Balfour (Chairman)
david.balfour@tll.co.nz

Wei Young Wang
wei-young.wang@pfolsen.co.nz

Nigel Heron
nigel.heron@tll.co.nz

MAF Biosecurity New Zealand

Paul Stevens
paul.stevens@maf.govt.nz

NZ Forest Health Collaborative

Mark Forward
mark.forward@nelsonforests.com

Scion

Brian Richardson
brian.richardson@scionresearch.co.nz

Lindsay Bulman
lindsay.bulman@scionresearch.co.nz

Bio-Protection Research Centre, Lincoln University

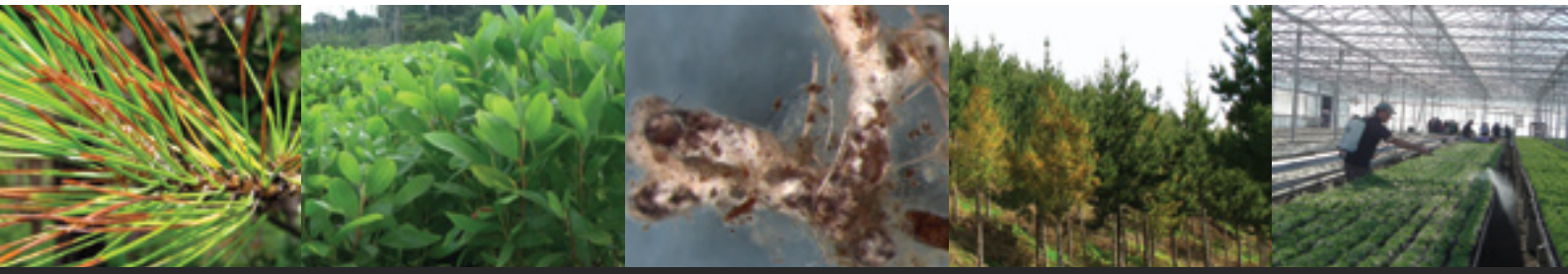
Robert Hill
robert.hill@lincoln.ac.nz

Radiata Pine Breeding Company Ltd

John Butcher
john.butcher@rpbc.co.nz

FBRC Administrator

Don Hammond
don@hrml.co.nz



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