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OUR PARTNERS
BIO-PROTECTION RESEARCH CENTRE

The Bio-Protection Research Centre is focused on novel research that will lead to natural and sustainable solutions for controlling plant pests, weeds and diseases in New Zealand.

OUR MISSION

Our aim is to develop sustainable pest management solutions that will help New Zealand’s plant-based primary production to flourish, while maintaining our pristine natural environment.

OUR RESEARCH

New Zealand researchers are world-leading in the areas of biocontrol, biosecurity and plant pest management. However, risks are constantly changing and we face new challenges with climate change, shifts in agricultural land use, increasing trade and passenger volumes, and the latest consumer perceptions. Research in the Centre aims to support the exclusion, eradication and effective management of threats to plant species to enhance New Zealand’s economy, environment, and human health and well-being.

MĀTAURANGA MĀORI

The Centre integrates Māori bioprotection technologies across all of its research areas. We have a network of Māori researchers and established relationships within Māori communities that are helping to support opportunities for new research and education.

OUR BACKGROUND

We are a Centre of Research Excellence funded by the Tertiary Education Commission since 2003. The Centre has seven partner institutes: Lincoln University, Massey University, University of Canterbury, University of Otago, AgResearch, Plant & Food Research and Scion.

This Annual Report outlines the key achievements and highlights from the Bio-Protection Research Centre in 2018.
OVERVIEW

FROM THE CHAIR & DIRECTOR

Plant protection, which ranges from pre-border biosecurity to long-term management of intractable invertebrate pests, plant disease, and weeds, has been of crucial importance to New Zealand’s prosperity since crops have been grown here. The risks are arguably greater today than ever before, given increasing trade, decreasing pesticide availability, and changing climate. So the need for fundamental research in plant protection to establish cross-sector understanding is paramount.

The Bio-Protection Research Centre, with our partner institutes and national and international collaborators, is unravelling some of the most difficult questions in plant protection. In this annual report you will see stories on understanding why some organisms become invasive, how bacteria become pathogens, why biocontrol can fail, and how endophytes colonise plants. We also report on studies on complex systems – how organisms interact in the real world. These projects, while delivering fantastic science, may seem to be nice to know rather than driving change in pest management, but they provide the understanding needed to find future solutions.

Over the past year, as we travelled around the country discussing our research with Government and industry, it was pleasing how much they “got” the importance of targeted, fundamental research. It is no longer a hard sell to show the merits of understanding why things happen and, through our aligned research, how we can translate this into solutions.

This has been another excellent year for the Centre, the third in our current funding cycle. All our post-doctoral and student projects are underway and we are starting to see quality publications and other outputs from the research. One cornerstone of our Centre of Research Excellence is the development of the next generation of talented scientists. You can see from the stories in this report that we have a group of extremely accomplished young researchers who will move to other organisations and new research. They represent the future of bioprotection in New Zealand.

We continue to be very well supported by our partners and our board. It is important to the success of a multi-institute organisation that governance keeps the leadership team focused and provides strategic direction. To enhance the board’s ability to do this, in 2018 we reduced the board from 11 members to eight.

Finally, a word from John: This is my last report as Chair. It has been a privilege for me to have been in this leadership role for an organisation of extremely bright staff undertaking excellent research in an area vital to New Zealand’s prosperity.
In 2018 the Bio-Protection Research Centre was in its third year of a five-year research programme, funded by the Tertiary Education Commission. This report highlights progress on continuing research projects, new research projects, and collaboration and engagement with other researchers, industries, and the public.

STRENGTHENING CONNECTIONS

• In 2018 we welcomed the University of Otago as our seventh full partner. This formal agreement brings some very high-calibre researchers within the Centre’s fold. Read more on page 19.

• A half-day visit by the Board of TomatoesNZ led to closer connections between the industry and the Centre, including funding of a PhD scholarship to develop further biological control of the tomato potato psyllid. Read more on pages 40 and 41.

• Our researchers supervised and mentored international students from around the globe, helping to develop the next generation of international bioprotection scientists. Read more on pages 15 and 16.

RESEARCH DEVELOPMENTS

• After an 18-month large-scale mesocosm experiment, we found that the effects of alien plants on ecosystem carbon cycling depend on soil biota and herbivores, suggesting that understanding cross-taxa interactions is critical for the future of bioprotection. Coupled with experiments showing that soil biota and above-ground herbivores drive strong indirect effects of invasive plants, our understanding of the complexity of invasion is advancing. Read more on page 11.

• We identified effectors with key roles in the pathogenicity of *Pseudomonas syringae* pv. *actinidiae* (Psa) on *Actinidia chinensis* and *Phytophthora agathicida* on kauri. This is leading to new approaches to controlling these diseases. Read more on page 8.

• We have demonstrated evasive behaviour by the Argentine stem weevil (*Listronotus bonanensis*) against the parasitoid wasp *Microctonus aethiopoides*, strongly associated with a north-south decline in parasitism collapse. Read more on page 7.

SOLVING REAL WORLD PROBLEMS

• Continued work by scientists from Massey University and other Centre partners is resulting in diagnostic tests that can be used in the field, and yield results more quickly and cheaply than traditional laboratory testing. Read more on page 21.

• Our scientists developed a method of using stable isotope analysis to help determine the geographical origin of newly discovered exotic pests. Read more on page 22.

• PhD student Rowan Sprague developed an algorithm that helps to spot wilding pines using image data collected from satellites and aircraft. As a result of her research she is now working as co-ordinator of the New Zealand Wilding Conifer Trust. Read more on pages 21 and 26.
RESEARCH PROJECTS

Erin Stroud, BSc Hons Student, Dr Jay Jayaraman, Researcher
Credit: Plant & Food Research
PROJECT 1: CONTEMPORARY EVOLUTION IN WEED INVASION: ENEMY RELEASE, NICHE SHIFTS & HYBRIDISATION

HIGHLIGHTS

- Analysis of almost 5000 *Rumex* leaf samples from the United Kingdom and New Zealand shows herbivory damage is five times higher in the native than introduced range.
- A large-scale assessment of plasticity revealed genotypes from both the native and introduced range are highly plastic and tolerate 10-fold differences in soil moisture.
- Research highlighted niche shifts in all assessed ranges around the world with little overlap between native and introduced ranges.

OVERVIEW

This project tests whether, compared with plants in their native ranges, invasive weeds in New Zealand show:

- greater adaptive variation to environments; broader environmental tolerances; stronger competitive abilities; and increased likelihood of hybridisation.

PROGRESS

Quantitative comparison of herbivory rates from a sample of almost 5000 leaves revealed 3.7% damage to the UK plants compared with 0.6% damage to the New Zealand plants, but no difference between the three *Rumex* species. However, damage levels were low in both regions, showing this species is not particularly palatable to chewing invertebrates. Chemical analysis of leaves shows high levels of oxalate, but no difference in levels between the two countries.

We compared the climate profile of the native range of *R. conglomeratus* to six climatically different ranges where it has been introduced worldwide. The species experienced niche shifts between all ranges, with little overlap. The niche shifts were not consistent in either strength or direction, highlighting the dangers of using only native range climate profiles to predict invasion risk.

FUTURE FOCUS

We aim to measure ploidy and genome size in native and introduced provenances of *Rumex* species to estimate population admixture and how genetic and geographic distance affect offspring fitness. We will measure genetic admixture using genotyping-by-sequencing. This will help to explain whether there is a genetic shift that can help invasive plant species, and to see what has happened since introduction.

We will analyse herbivore damage of *Rumex* species from different provenances, grown together in New Zealand, to show which shifts in susceptibility have occurred since introduction. We will compare these patterns to variation in plant chemistry.

We will use niche modelling to determine environmental parameters that delimit *Rumex* distribution in New Zealand, and the roles of climate, land-use, and anthropogenic factors on weed prevalence.

RESEARCH TEAM

Project leader: Prof Philip Hulme
Researchers: Drs Will Godsoe and Jennifer Bufford
PhD students: Tom Carlin, Andrei Costan, Sandra Savinen
PROJECT 2: INTRODUCED BIOLOGICAL CONTROL

HIGHLIGHTS

- We have demonstrated evasive behaviour by the Argentine stem weevil (*Listronotus bonariensis*) against the parasitoid wasp *Microctonus aethiopoides*, strongly associated with a north-south decline in parasitism collapse.
- We have sequenced the genomes of the parasitoid and the weevil and the weevil shows far more genetic variability than expected.
- We developed models based on empirical parameters that predicted field results.

OVERVIEW

Project 2 has clearly shown that parasitism decline in the weevils relates to levels of evasive behaviour. We found this occurred along a north-south gradient from Waikato to Otago. Similarly, field levels of parasitism on different grass types varied according to weevil evasive behaviour. Such results point very strongly to adapted behaviours against the parasitoid.

PROGRESS

At the end of 2017 we were still hypothesising an evasive response. Our work over the last year has strongly supported this hypothesis.

We achieved this via multiple laboratory-based observational studies on different types of grass and, separately, by using weevils collected from different parts of New Zealand. These trends were not immediately apparent in the plethora of data collected, but were found to be highly significant subject to detailed statistical analysis.

The progress made in the genotyping of the weevil and the parasitoid now presents an immediate opportunity for us to find the genetic basis for these recent discoveries. That has led us to suspect rapid evolution, strongly influenced by New Zealand’s unique pasture ecosystem.

From an ecological point of view the asexual parasitoid, which can’t evolve, versus the sexual weevil, which can, generates expectations that fit with field-collected data. Our modelling shows that resistance is inevitable when species differ in reproductive strategies in this way.

Overall, the ecological circumstances in non-diverse New Zealand pasture, combined with the genetics, point to these outcomes.

FUTURE FOCUS

We will continue to add to a series of publications. We anticipate now that we will make major progress in applying already-completed genomic studies to understand the role of evolution in the loss of parasitism. We should then be able to connect how New Zealand’s ecosystems have led to these very unusual results.

We believe that these behavioural and genetic findings, combined with population modelling, are now allowing us to contribute to international biological control theory.

RESEARCH TEAM

Project leader: Prof Stephen Goldson
Researchers: Profs Peter Dearden, Jason Tylianakis, Steve Wratten,
Drs Paula Casanovas, Tom Harrop, Shola Olaniyan
PhD students: Morgan Shields, John Skelly, Luis Ferreira Maia
Masters student: Sarah Inward (aligned)
RESEARCH PROJECTS

PROJECT 3: PATHOGEN VIRULENCE AND PLANT DEFENCE

HIGHLIGHTS

• We showed that a subset of the RxLR effector proteins of Phytophthora agathidicida with virulence and avirulence functions are expressed in kauri roots. We began work to identify which Nicotiana benthamiana immune receptors are involved in recognising these proteins, leading to a defence response.

• We identified effectors with key roles in the pathogenicity of Pseudomonas syringae pv. actinidiae (Psa) on Actinidia chinensis. We also found effectors that trigger resistance to Psa in other Actinidia species.

OVERVIEW

Understanding how pathogens evolve and cause disease is central to protecting our productive sector and conservation estate. The team is working on two projects. We are investigating:

• the disease determinants and origins of Phytophthora agathidicida, which causes kauri dieback

• how plant pathogenic bacteria such as Psa and Serratia evolve and cause disease.

PROGRESS

In 2018 we showed that some P. agathidicida RxLR effector proteins with virulence and avirulence functions were expressed in kauri roots. We also gained an opportunity to identify which Nicotiana benthamiana immune receptors are involved in recognising these proteins, leading to a defence response. The experiments, which involve RNA silencing specific N. benthamiana immune receptors, show promising results. In future, kauri could be screened for orthologues of these receptors, to select and breed for resistance.

Using a gene-knockout strategy we identified the key effectors in Psa responsible for causing disease in A. chinensis. These are a subset of the 30+ active effectors identified in the Psa genome, suggesting redundancy in the Psa effector repertoire. We identified effectors recognised by disease resistance genes present in other Actinidia species, important for breeding resistance to Psa in future cultivars.

FUTURE FOCUS

• We will follow up Scion experiments that suggest N. benthamiana is a host for P. agathidicida, and pursue options for work on kauri. A genome-wide transcriptome of P. agathidicida in kauri will enable identification of other potential effectors. We will study virulence and avirulence functions in more detail because host resistance triggered by effectors with critical virulence functions is more likely to be durable than that based on effectors with dispensable functions.

• We will investigate why the seemingly redundant effectors in Psa are retained: are they required for pathogenicity on other Actinidia species?

RESEARCH TEAM

Project leader: Assoc Prof Matt Templeton
Researchers: Profs Rosie Bradshaw, Peter Fineran, Peter Lockhart; Drs Paul Dijkwel, Paul Gardner, Melissa Guo, Jay Jayaraman, Rebecca McDougal, Carl Mesarich, Andrew Pitman, Hayley Ridgway, Richard Winkworth
PhD students: Aroa Rey Campa, Bethany Jose, Ellie Bradley, Thomas Nicholson
BSc (honours) students: Emma Applegate, Erin Stroud (aligned)
PROJECT 4: ENHANCING BENEFICIAL ENDOPHYTES

HIGHLIGHTS

• We determined the telomere-to-telomere assembly of the Epichloë festucae endophyte genome and resolved its 3D organisation in the nucleus.

• We identified a functional homologue of the gene encoding peramine synthetase in the genome of the insect pathogenic fungus Metarhizium rileyi.

• Collaborating with United States researchers at the Noble Research Institute, we have generated telomere-to-telomere assemblies of two additional species of Epichloë and a high-quality assembly of an interspecific hybrid derived from these species.

• Analysing the secretome of Trichoderma virens in association with maize roots, we identified fungal and plant protein differences consistent with host defence suppression.

OVERVIEW

Mutualistic symbiotic associations between fungi and plants are vital in protecting hosts from environmental and biological stresses. We are researching two agriculturally important associations:

• above-ground associations between Epichloë endophytes and grasses

• below-ground associations between Trichoderma and maize.

We aim to understand how these fungi suppress host defence and are metabolically reprogrammed to protect their hosts.

PROGRESS

• We identified an amino acid glycoside in the apoplastic fluid of Epichloë festucae-infected ryegrass, encoded by a cluster of genes that are highly expressed in planta.

• We showed that just perA is required for synthesising peramine in E. festucae. We identified a functional homologue of this gene in Metarhizium rileyi, but in this fungus perA is embedded within a seven-gene cluster, suggesting that peramine is the substrate for synthesis of more complex metabolites.

• Identifying the structure of stromatine, a metabolite proposed to trigger sexual development in Epichloë, will be a high priority. We also plan to determine the plant phenotype of mutants in this pathway and how the transcriptome changes during stromata development.

• In our Trichoderma programme we will further analyse the role of fungal terpene synthetases in regulating host defence and how these volatiles reprogramme host metabolism.

FUTURE FOCUS

• We will use the genomes of the interspecific hybrid E. canadensis and the two haploid parents to analyse how the transcriptome has been reprogrammed following interspecific hybridisation.

• We will continue collaborating with researchers in Germany to identify the structure of the novel amino acid glycoside in ryegrass apoplastic fluid. We will test whether a related metabolite is present in the apoplast of wheat infected with the pathogen Zymoseptoria tritici.

• We will continue collaborating with researchers in the United States to identify the structure of the novel amino acid glycoside in apoplastic fluid and to test whether a related metabolite is present in the apoplast of wheat infected with the pathogen Zymoseptoria tritici.

RESEARCH TEAM

Project leader: Prof Barry Scott
Researchers: Profs Murray Cox, Peter Fineran; Drs Daniel Berry, Kimberly Green, Carl Masarich, Artemio Mendoza-Mendoza, Michael Rostás, David Winter, Baojun Wu
PhD students: Bent Hosking, Fabiola Padilla
Masters students: Alyesha Candy
PROJECT 5: ENHANCING MICROBIAL-BASED BIOLOGICAL CONTROL

HIGHLIGHTS

• We sequenced genomes of over 60 Serratia species, meaning we could begin analysing the relationship between plasmids, chromosomes, and disease-causing ability. We compared the amber-disease-encoding plasmids and identified clear segments subject to horizontal gene transfer.

• We completed our global study on the distribution of insecticidal and antimicrobial toxin-encoding genes in the bacterium Brevibacillus laterosporus, showing that New Zealand strains are likely a new species. All strains had a novel combination of known toxin-encoding genes, suggesting constant gene transfer rather than evolutionary change.

OVERVIEW

Project 5 addresses key biological questions using bacterial insect pathogens as the model system. We are examining how pathogenic and non-pathogenic bacteria interact in soil, in the presence of the host insect, and how transfer of virulence determinants between pathogenic and non-pathogenic bacteria affect the ecological equilibrium. We will use the results to better inform the use of bacterial insect pathogens (such as AGR96X currently under development as a biopesticide) as applied biocontrol agents.

PROGRESS

We have compared plasmids from several bacteria related to amber-disease-encoding and hypervirulent-encoding bacteria, determining the range of genotypes involved and where horizontal gene transfer has occurred. This PhD project is nearing completion.

We also sequenced, assembled, and aligned the genomes of over 60 bacteria (mainly Serratia and Yersinia). We are now examining these genomes and investigating secondary elements of interest, and mutations that began in these areas. We also determined the geographic distribution of genotypes of Serratia.

We have completed comparison of known genomes of the insecticidal bacterium Brevibacillus laterosporus. Toxin-encoding gene distribution of strains from around the world show an almost random occurrence, suggesting horizontal gene transfer is common.

FUTURE FOCUS

• Completing study of plasmid variation and gene acquisition in Serratia species, with reference to bacteria causing amber disease of grass grub.

• Defining S. entomophila genome determinants leading it on a commensal path.

• Determining horizontal gene transfer between soil-inhabiting, disease-causing bacteria in real time, and the influence of biotic and abiotic factors on these processes. This will allow us to predict factors affecting the efficacy of an applied pathogen, specifically if the presence of plasmid-free strains affect efficacy.

• Completing study of chromosomal influence on disease-causing plasmid acquisition and retention in a bacterial system. The model system will allow prediction of the specific gene(s) required for successful plasmid retention.

RESEARCH TEAM

Project leader: Prof Travis Glare
Researchers: Profs Murray Cox, Peter Fineran; Drs Paul Gardner, Alexandra Gavryushkina, Mark Hurst
PhD students: Lesley Sitter, Amy Vaughan, Connor Watson
PROJECT 6: ACHIEVING BIOPROTECTION IN NEW ZEALAND ECOSYSTEMS

HIGHLIGHTS
In field and greenhouse experiments, we have shown that soil biota and above-ground herbivores drive strong indirect effects of invasive broom on other plants, particularly alien legumes.

Our mesocosm experiment has found that the effects of alien plants on ecosystem carbon cycling depend on both soil biota and herbivores, suggesting that understanding cross-taxon interactions is critical for the future of bioprotection.

OVERVIEW
Invasive weeds are a key challenge facing New Zealand’s productive and conservation grassland ecosystems. While direct impacts of weeds are often clear, indirect impacts via herbivores, pathogens, and microbial mutualists are poorly understood.

An interdisciplinary approach combining the most recent molecular tools, highly replicated manipulative experiments, field surveys, and network theory is allowing us to understand these complex, multi-taxon interactions.

Ultimately, we aim for a paradigm shift in pasture management from diverse to designed pastures, with plant species composition managed to maximise productivity and resilience.

PROGRESS
In 2018, we harvested our mesocosm experiment and are now analysing DNA. Ecosystem functions (particularly carbon cycling) showed that the effects of invasive species depend on both soil biota and herbivores.

We also harvested a large field experiment. Early results show that the effects of invasive broom on other plants depend on soil biological linkages and herbivore interactions. Invasive broom has strong positive indirect effects on other alien legumes.

FUTURE FOCUS
Our primary focus in 2019 will be on bioinformatics, data analysis, network theory, and communicating our findings. We will conduct a meta-barcoding bioinformatics workshop for postdoctoral fellows and PhD students working with next-generation sequencing, ensuring consistency and quality through this critical step.

While our current data focuses on describing networks of plants, microbes and herbivores and how these networks influence ecosystem function, a major new area of research will be in determining the factors that shape different organism roles in networks.

We will conduct manipulative experiments to determine if plants can select microbes that are optimised to complement plant traits. Complementing this work, we are developing network analysis approaches to test how conserved species roles are across networks and whether roles switch under different settings, including increasing levels of alien plant invasion.

RESEARCH TEAM
Project leader: Prof Ian Dickie
Researchers: Prof Jason Tylianakis, Leo Condon, Drs Warwick Allen, Barbara Barratt, Beccy Garley, Xiaoben Jiang, Eirian Jones, Maureen O’Callaghan, Alexandra Puriotósz, Hayley Ridgway, Jonathan Tonkin, Steve Wakelin, Lauren Waller
PhD students: Ralph Wainer, John Ramana
PROJECT 7: MĀORI BIOPROTECTION: DO FRAGMENTED KAURI ECOSYSTEMS FACILITATE PATHOGEN SPREAD?

HIGHLIGHTS

• With kauri dieback being a major news story in 2018, Centre researchers and allies contributed significantly to the conservation, with opinion pieces and comment published in Nature, the New Zealand Herald, and the Guardian.

• Kai Lewis completed his MSc, “Characterising the growth response and pathogenicity of Phytophthora agathidicida in soils from contrasting land-uses,” showing that P. agathidicida can live in soils outside kauri forests.

• We characterised fungi and bacteria in soils from uninfected and infected sites, and identified soil fungi and yeast for biocontrol screening against P. agathidicida.

OVERVIEW

This project is testing whether disrupted interaction networks, within fragmented forest, and abiotic soil changes, associated with agricultural intensification, facilitate the establishment, rapid adaptation, and subsequent spread of the pathogen causing kauri dieback. The work takes place in Waipoua Forest, in collaboration with Te Roroa iwi.

PROGRESS

We are continuing to investigate changes in the soil microbe community across the three land-use changes. We are especially focusing on community differences between uninfected kauri sites and infected sites within Waipoua Forest, and whether these differences help or suppress the survival and sporulation of P. agathidicida.

We have identified soil fungi for biocontrol assays from the soil micro-organism community analysis.

The research team is continuing to collaborate with teams from other institutions (University of Otago, Victoria University), all working to find an answer to this pressing biosecurity threat.

FUTURE FOCUS

In 2019 we will be designing and initiating two MSc projects:

• The first project will focus on the impacts of root exudates from native plants identified from an aligned MBIE programme (Mātauranga Māori guided discovery and development of new control methods for Phytophthora) on the growth and sporulation of P. agathidicida in soils.

• The second project will focus on the soil fungal and bacterial communities from asymptomatic or uninfected sites on Great Barrier Island, as a comparison to soil microbial community findings in Waipoua Forest.

We will also screen infected kauri seedlings, using soil fungi and yeast isolated from asymptomatic or uninfected soils from Waipoua, to test for potential biocontrol agents.

RESEARCH TEAM

Project leader: Dr Amanda Black
Researchers: Prof Leo Condron, Drs Maureen O’Callaghan, Peter Scott, Nick Waipara, Nari Williams
PhD student: Alexa Byers
Masters student: Kai Lewis
STRATEGIC OUTCOMES

Lais Ferreira Maia, PhD Candidate
The Bio-Protection Research Centre’s key strategic outcomes are:

**NETWORKS OF EXPERTISE**
A Centre of Research Excellence comprising a network of bioprotection researchers – including multiple universities, Crown Research Institutes and international collaborators – that is nationally and internationally recognised and sought after for its expertise and innovation in bioprotection and biosecurity.

**DEVELOPING INNOVATIVE TOOLS**
New Zealand’s continued prosperity and well-being will be protected by developing new and innovative methods to combat invasive species that put economically important industries at risk, and improve industry and government decision-making.

**PROTECTING THE ENVIRONMENT**
New Zealand maintains productive and native environments in the face of multiple and diverse threats to sustainability, to underpin the strong ‘clean green’ New Zealand brand, while maintaining productivity on-farm.

**GLOBAL CAPABILITY**
A cohort of graduates and postdoctoral researchers who have received outstanding training and education in bioprotection, are placed in New Zealand institutes, industry, and government – as well as overseas – ensuring long-term economic and environmental sustainability of New Zealand’s primary sector and enhanced science excellence and innovation, bringing about greater global connectivity.

**VALUING MĀTAURANGA MĀORI**
The Centre will develop research specifically with and for Māori communities, addressing pest and pathogen threats to native forests both in intact and fragmented landscapes so that Māori are ensured of protection of indigenous ecosystems and Māori agricultural interests.

The following pages outline how we worked to meet these outcomes in 2018.
GLOBETROTTING STUDENT TACKLES INSECT PEST TRAPPING

Bio-Protection Research Centre student Karla López-Reyes is collaborating with scientists around the world to study insect vision and design the perfect trap for greenhouse pests.

Insect pests, like Western flower thrips, are a huge problem for growers. They damage vegetables, fruits and flowers and can also spread viruses and disease through crops.

Traditional greenhouse trap systems are not very effective, sometimes trapping less than 15% of pests. Karla is investigating whether this is because the thrips can’t see the traps well. A better trapping system needs to attract insect pests in high numbers she explains, reducing the need for synthetic pesticides.

The Guatemalan student is working with insect behaviour specialist Dr Rob van Tol at Wageningen University & Research, the Netherlands, to investigate what colours, or specific light wavelengths, are most attractive to Western flower thrips.

“One challenge for us is to try to create a trap that will attract the thrips, and encourage them to leave the safety of the host plant,” says Karla. Western flower thrips, just 2 mm long, like to hide in small places and readily evade detection.

Karla is monitoring the thrips’ response to different wavelengths of light. She tracks their flight path via specialised video equipment and traps them with sticky paper at the light source. Ideally, Karla would like to find light wavelengths that attract thrips but not beneficial insects. Most greenhouses use blue or yellow traps she explains, but there is debate over which is the most attractive.

With the first phase of her project almost complete, it seems the thrips in her study prefer yellow. Next, Karla will travel to the University of Bristol, United Kingdom, to work with Dr Michael Bok to find out more about how thrips’ eyes work. Like most insects, they have compound eyes with many lenses. She will examine their eye structure, light sensitive proteins and pigments, and visual fields to get a better idea of how they see the world.

Once this research is completed, Karla will return to Lincoln University to bring together all she has learned, and design and trial new traps. The aim is to attract thrips en masse, disable them, and protect greenhouse crops without the need for synthetic pesticides.

This research is a key part of a joint programme to improve monitoring and mass-trapping of pest insects that involves Lincoln University (New Zealand), Plant & Food Research (New Zealand), Wageningen (Netherlands) and Lund University (Sweden).
If today’s students are tomorrow’s researchers, the Centre is playing an important role in setting up the discoveries of the future.

That applies not only to the Centre’s postgraduate students, but also to students at overseas universities.

Emir Padilla is one such student. Studying for a Bachelor of Genomic Science at the National University of Mexico, he approached research officer Dr Artemio Mendoza-Mendoza who was in that country to talk about the Centre’s research into Trichoderma.

As a result, he spent six months last year co-supervised by Artemio and Dr Chris Brown from the University of Otago, annotating the Trichoderma genome. Artemio wanted to do this work for several years, but lacked the student resources. Emir needed a practical work placement for his degree – it was a perfect fit.

In 2018, several students from the United States and France also benefitted from the Centre’s guidance and tuition.

Among them was Gillian Bergmann, studying for an honours degree at Oregon State University. Based at Lincoln University, she characterised the seed endophytes of Douglas fir in New Zealand plantations, to compare them to the native endophyte communities in the US. Compatriot Diana Kulawiec, enrolled in a BSc at Rochester Institute of Technology, also spent time in New Zealand characterising the insecticidal toxin genes in the bacterium Brevibacillus laterosporus.

From France Eléonor Michaud and Nathalie Cayla, studying agricultural engineering at Agrocampus Ouest School of Agronomy, spent five-month internships at the Centre, supervised by Prof Steve Wratten.

Nathalie extended her internship for two months. “I’ve grown in my scientific career, acquiring a lot of knowledge and skills, but I’ve also met such an amazing, enthusiastic scientific team.”

Several overseas postgraduate students also benefited from the Centre’s international linkages. Artemio co-supervised Cynthia Cocot Castaneda studying at the Polytechnic University of Pachuca, Mexico. She recently submitted her PhD thesis, including description of a novel transcription factor which controls lytic enzymes by a newly discovered mechanism.

Valter Magalhaes-Cruz, a PhD student at the University of Santa Cruz, Brazil, also has Artemio as a co-supervisor. And Veronica López Calva, a Master’s student at the Polytechnic University of Pachuca, has engaged Artemio to be an assessor for her research.

“These arrangements are very good for the students, as they get to experience different laboratories and research institutions, and understand different ways of working,” says Artemio.

“And they are very good for the Centre because they keep us engaged with the researchers who will become the future of bioprotection science.”
IMPROVED BIOLOGICAL CONTROL OF PSA

For 3½ years Lincoln-based PhD student Jessica Yardley worked on a biological control agent to help combat the bacterial kiwifruit pathogen *Pseudomonas syringae pv. actinidiae* (Psa).

Last year she submitted her PhD thesis, showing an encouraging copper-tolerant strain of *Trichoderma* could be produced on a commercial scale and used to control copper-resistant Psa.

Copper spray is a major tool against Psa, but the bacterium has developed some tolerance, so there has been a lot of interest in developing complementary tools.

Jessica tested the strains of the fungus *Trichoderma* that are in the biocontrol agent KiwiVax to see if they could become copper-tolerant.

She used a technology called protoplast regeneration, which involves dissolving fungi cell membranes and exposing them to the substance they need to become tolerant to. The fungi that became tolerant to copper passed that property on to future generations. It’s a method that could be used to make commercial quantities of copper-tolerant *Trichoderma*.

Some issues still need to be researched. “We don’t know exactly what mechanism has caused the copper-tolerance, and whether that change has any unknown side effects,” Jessica says.

Once those questions are answered, the way is open for further research to develop copper-tolerant *Trichoderma* into a biocontrol agent against Psa.

FINDING THE SWITCH TO A BIOPESTICIDE

Discovering an organism that could become a biopesticide is the first step in developing a commercially viable product.

AgResearch and Bio-Protection Research Centre PhD candidate Marion Schoof has played her part, trying to develop the bacterium *Yersinia entomophaga* into a broad-spectrum biopesticide.

More than 20 years ago, AgResearch scientist Mark Hurst isolated *Y. entomophaga* and showed it was active against a broad range of insect pests.

Using this method with *Y. entomophaga*, Marion identified “a very interesting genetic region” which appears to regulate protein secretion.

In August Marion presented her work to the Society for Invertebrate Pathology (SIP) meeting and won third prize in the student oral presentation category.

“I hope this will contribute to the production of a safe and sustainable biopesticide against a broad range of New Zealand’s pasture pests,” she says.
NEW TOOL IDENTIFIES EMERGING DISEASES BEFORE THEY DO HARM

Scientists from New Zealand, the United Kingdom and Germany have developed a tool that can tell if new pathogens are likely to be deadly.

Dr Paul Gardner of the Bio-Protection Research Centre, based at Otago University, Dr Nicole Wheeler (Sanger Institute, United Kingdom), and Dr Lars Barquist (University of Wuerzburg, Germany) last year published their predictive computer algorithm in the journal PLOS Genetics.

Paul says the research began because it was difficult to work out which genes in any organism were responsible for different effects. For example, why are only some strains of *Salmonella enterica* (pictured) deadly? Or why do only some plants become invasive?

Using a method called a “random forest classifier”, the scientists taught a computer to analyse 13 strains of *S. enterica* and work out which mutations caused serious illness, and which caused less serious food poisoning. It then predicted whether strains it had never encountered before caused serious disease or not.

Using the same method, Paul says bioprotection scientists could identify which mutations of the kiwifruit pest *Pseudomonas syringae* p.v. *actinidiae* (Psa) cause disease, and target them.

They could also determine which exotic plants were likely to become invasive, and stop them entering the country. “You can use this approach with just about any genome, to distinguish just about any trait or characteristic.”

Fungi show promise in controlling diamondback moth

New Bio-Protection Research Centre research suggests there’s more to cabbages than meets the eye.

Lincoln-based PhD student Michal Kuchár has been investigating the fungi that live on or in Brassica plants, looking for some that can be harnessed for pest protection. He used two methods to uncover the fungi: culturing and metabarcoding (a variant of next-generation sequencing).

He has identified more than 100 species of fungi through culturing and 250 through metabarcoding. Forty-six were identified by both methods, and there were up to 15 on any one plant.

“There is a rich diversity of organisms living on plants that are very probably contributing to plant health,” says Michal.

The fungi are specific about which part of the crop they inhabit, with some above ground while others are below ground. They can all affect the whole plant for the better or worse. Several appear to be active against diamondback moth, a significant insect pest of Brassica crops.

“We need to understand which niche each fungi works in, so we can develop them as targeted bio-control agents,” says Michal. “More work needs to be done if they are to be commercialised – but this is a promising start.”

Michal’s research is co-funded by the Foundation for Arable Research, Grasslanz, and the Ministry of Business, Innovation and Employment.
OTAGO BECOMES FULL PARTNER

When the Bio-Protection Research Centre was established as a Centre of Research Excellence (CoRE), in 2003, it started with four partners: the Crown Research Institutes (CRIs) Plant & Food Research (originally Crop and Food) and AgResearch, and Massey and Lincoln universities.

Over recent years the partnership has increased, as the Centre’s cross-sector benefits have been realised and more outstanding researchers join the research effort. The forest research CRI Scion joined in 2014, followed by the University of Canterbury in 2017.

This year, the Centre has been pleased to have the University of Otago join as a full member. This growing partnership is recognition of the value of a CoRE in enhancing collaborations across New Zealand, and the excellent bioprotection researchers in each institute.

Otago has brought a number of highly acclaimed researchers to the Centre, especially in the areas of genomics, bioinformatics and bacterial genetics. They are working across a range of our projects, several of which are highlighted in this Annual Report.

One of the key benefits of a CoRE is to allow researchers to make new connections across institutes. The Otago-based researchers have taken advantage of this and now work in three of our seven projects.

SOCIETY FOR INVERTEBRATE PATHOLOGY ANNUAL MEETING

Invertebrate pathology, or the study of insect diseases, is one of the Centre’s specialist disciplines. Insect diseases can threaten some of our most beneficial insects, such as bees, but increasingly we are looking at insect disease-causing organisms as potential biocontrol agents.

Next-Generation Biopesticides is one of our aligned programmes, funded by industry and the Ministry of Business Innovation & Employment (MBIE). It includes a significant focus on insect disease-causing organisms, as we look for future biopesticide solutions to New Zealand’s insect pest problems. So it was significant that the annual meeting of the Society for Invertebrate Pathology was held on Gold Coast, Australia, in August 2018.

A number of Centre researchers were involved in the organisation and our staff and students attended and gained valuable exposure to international research and researchers. With 146 oral presentations and 74 posters over the five days, a lot of exciting science was discussed. One of our own students, Marion Schoof (AgResearch and Lincoln University), won a prize for her oral presentation (see page 27).
SCIENTISTS KEEN TO EXPLORE BIOLOGICAL CONTROL

An international workshop on conservation biological control of insect pests, hosted at Lincoln University by the Bio-Protection Research Centre, has been so successful organisers are planning a follow-up in 2019.

Led by Prof Steve Wratten (Lincoln University), Prof Geoff Gurr (Charles Sturt University, Australia), Dr Kris Wyckhuys (Vietnam), and Dr Jonathan Lundgren (USA), the workshop targeted graduate students and early-career scientists researching or working on biological control. It followed a similar workshop held in Hanoi (Vietnam) and Beijing (China) in 2017, and combined presentations, experiments, field visits, and discussions.

“Of the three main types of biological control of insect pests, conservation biological control is the newest and fastest growing,” said Prof Wratten. “This indicates the importance of this sustainable approach to pest management.”

The 30 participants were from 13 countries, as diverse as the United Kingdom, China, and Chile. Feedback showed that for most the workshop met or exceeded their expectations. “The workshop renewed my enthusiasm for conservation biological control and has helped me to think more of its impact in a global context,” said one.

Several others said the workshop had made them think hard about the importance of communicating science well to farmers, and one said they would like to hear first-hand from landowners trying to implement biocontrol.

Prof Wratten said one of the failings of research on agro-ecology was that most did not address the issue of “pathways to implementation”.

“ Websites and leaflets are delivery systems, but these often do not effect change,” he said. “This workshop covered how to establish those pathways.”

Marie Joy Beltran and Annabelle Albaytar, both from the University of Philippines Los Baños, said that while conservation biological control was not entirely a new concept in the Philippines, very few researchers worked in this field.

“The most we can do at this time is to equip ourselves with the necessary information concerning conservation biological control, and then actually explore this field of research when there is a chance,” they said.

“ We think this is how we could achieve a long-term effect in our country – by setting an example so that other researchers could clearly see how and why it works, and eventually, could follow.”

Organisers are now planning this year’s follow-up workshop.

The workshop was sponsored by the International Organisation for Biological Control, the Food and Agriculture Organization of the United Nations, Bayer, and the Bio-Protection Research Centre.
SPOTTING WILDING PINES FROM SPACE

Drive around the wide landscapes of the Mackenzie Country and you’re bound to spot some wilding pines. Wilding pines have invaded 1.8 million hectares across New Zealand. For the past three years Bio-Protection Research Centre PhD candidate Rowan Sprague has worked on a way to find wilding pine trees in remote areas by using image data collected from satellites and aeroplanes – which could help to lower costs.

Rowan wrote a detection algorithm that lets a computer automatically process the image data and detect where the pines are.

“When I compared what the computer could detect with what I found and measured in the field, I found that it does appear to find all adult trees,” Rowan says.

“While the method isn’t perfect – and it’d be nearly impossible to get it to detect very small seedlings – it adds another tool to more easily and effectively find where the wilding pines are establishing.”

New Zealand spends millions of dollars each year trying to remove these trees. Te Uru Rākau – Forestry New Zealand alone funds a large project to control them, costing $16 million a year.

Rowan’s work has helped to overcome one of the major obstacles to controlling wilding pines – knowing exactly where they are.

QUICK, CHEAP TESTS ARE GAME-CHANGERS

Field testing for diseases and pathogens is set to become a lot easier, thanks to researchers from Massey University and other Centre partners. They have already created tests for Phytophthora agathicida and Austropuccinia psidii, the organisms responsible for kauri dieback and myrtle rust.

Cost and time have been major roadblocks to wider use of genetic testing, says Massey University’s Dr Richard Winkworth.

“Most DNA diagnostics are lab-based, requiring specialist equipment and staff,” he says. “However, new technologies mean quick, portable, and relatively cheap tests that can be done outside the lab are not just possible but, in some cases, a reality.”

Based on isothermal loop-mediated DNA amplification, or LAMP, technology, the tests have similar specificity and sensitivity to lab-based diagnostics. But they are cheaper and more robust.

“We developed a test for a fungal pathogen of tuatara that the Department of Conservation has used,” says Richard. “It cost just $3 to $5 per sample.”

Even before the rust is visible, a test for myrtle rust can detect if the fungus is present within 30 seconds.

Kauri dieback has been another target. “The P. agathicida LAMP test has been through laboratory validation,” says Richard. “Our approach reduces testing time from several weeks to just days, and cuts costs by perhaps as much as $100.”
Preventing high-risk exotic insects from establishing is the most effective way to protect our natural and crop estates. So eradicating any post-border detections is crucial and eminently preferable to the monetary, social, and environmental costs of long-term pest management.

Early detection improves the likelihood of successful eradication. But what does that first detection mean when there is no obvious evidence of a breeding population? Is it a new arrival needing a relatively low-key biosecurity response? Or is it recently established, demanding a significantly greater response costing potentially millions of dollars and disrupting people’s daily lives – such as the 2002 urban spray programme for the painted apple moth in West Auckland, and the movement restrictions for the Queensland fruit fly in 2015?

Centre scientists at Lincoln University are developing stable isotope technology to tackle this conundrum, based on the principle “you are what you eat.” Isotopes are nearly identical forms of an element, found naturally in the environment. The ratios of these isotopes are linked to geology and climate, and become incorporated into insect tissue through their diet.

Although used in fields as diverse as archaeology, forensics, and nutrition, stable isotope analysis for biosecurity presents specific technological hurdles.

“Unfortunately, we need more tissue than is available with only one or two insects found, and it takes weeks to get a result when there is the pressure of quick decision-making within days,” says senior researcher Dr Karen Armstrong.

“Our goals were way ahead of what current technology can offer, but with great collaborations at University of Otago and Queensland University of Technology we have overcome severe limitations,” says postdoctoral researcher Dr Peter Holder.

Now the team have made novel modifications to the mass spectrometry methods, “so this technique can work on one fruit fly – which is about as small as you can get – as well as deliver results within days rather than weeks”, says Peter.

“We also tested it on a brown marmorated stink bug found in New Zealand – results strongly suggested it was born in the Northern Hemisphere and not part of a local population, consistent with other evidence.”

Karen says that while there is more work to do, “now we can manage the impediments an incursion presents and at a much cheaper price”.

“For the first time this method of provenancing can really be used to make pest incursion investigators’ jobs much easier in justifying the level of resourcing for responses”.

Dr Karen Armstrong, Senior Researcher, Dr Peter Holder, Postdoctoral Fellow
DELVING INTO THE PAST FOR ANSWERS

What evidence is there of kauri dieback in Māori oral history, ancient wood, and written archives? Dr Amanda Black has been delving into the past to find out.

Amanda’s project began in 2017, investigating and comparing soil fungal and leaf endophyte communities from infected and healthy trees. This work, which complements ongoing work in a Centre project, showed distinct differences in endophyte communities.

In 2018 she began investigating traditional Māori knowledge about the disease.

Using local networks to find knowledge-holders, she interviewed kaumatua, carvers, iwi resource managers, kaitiaki, and rongoā experts to see if there are any oral records, or intergenerational knowledge, of tree diseases and forest dieback.

So far the answer has largely been “no”.

“What I’m finding so far is this disease seems to be very contemporary,” she says.

Amanda will do further interviews in 2019, extending south to Waikato. And over the summer of 2018-19, Nga Pae o te Māramatanga summer scholar Orini Herewini has been analysing historic written records, also searching for possible references to kauri dieback.

While Amanda is surprised not to have found any specific reference to kauri dieback, she sees this as an example of “participatory mapping” – seeing how people assimilate new knowledge and experience of the disease into existing cultural practices and values.

CO-OWNING BIOCONTROL

In another project begun in 2018, Amanda gained funding from Ngā Pae o te Māramatanga to investigate Māori views on biocontrol – and the potential for mātauranga Māori to contribute to risk assessments of new biocontrol candidates.

“We live in a bicultural society, and Māori are partners,” says Amanda. “Having these conversations early on can facilitate longevity in research.

“Innovating together benefits society. It’s about inclusion, rather than exclusion, and about understanding the values Māori are using to make decisions about biocontrol.”
OUR PEOPLE

Kai Lewis, BPRC Alumnus
Credit: Plant & Food Research
ALUMNI

AIMEE’S RESEARCH IS GLOBALLY IMPORTANT

With colony collapse disorder concerning scientists across the globe, one Centre graduate is researching one of the possible causes.

Aimee Mckinnon graduated in 2018 with a PhD from Lincoln University, her thesis titled “Interactions between isolates of the fungus Beauveria bassiana and Zea mays”.

Now she is a postdoctoral researcher in the Department of Ecology, Environment and Evolution at La Trobe University, Melbourne, investigating the impact of sublethal pesticide exposure on honey bees.

“In the short time I have been at La Trobe, I’ve connected with honey bee researchers from Sydney, Adelaide, and UC Davis, and initiated collaborations with them, as we are all working towards a common goal.

“I’ve also been working with commercial beekeepers from Monsons Honey and Pollination and Melbourne City Rooftop Honey. It is exciting for me to be connecting with academic researchers and with industry people.”

FROM LINCOLN TO UGANDA – VIA CHINA

Chris Littlejohn was a secondary school teacher before doing his PhD at Lincoln University, graduating in 2015.

His thesis investigated the benefits of shelterbelts created from Miscanthus, a tall energy plant.

After graduating he took a role as Dean of Nestle Dairy Farming Institute, Northern China, where temperatures get as high as 35°C and as low as minus 26°C.

Now he is Plantation and Research Manager at The Green Elephant Company, Uganda. “We are in the process of securing funding to research the potential of using a mobile bio-refinery to extract pure protein from Napier grass, to use in animal feed.”

“My PhD has given me the opportunity to travel and experience different cultures,” says Chris. “The expertise I gained is in a field that is highly relevant. It is also very rewarding to see where my work can have an immediate impact on improving peoples lives.”

FOUR AMAZING YEARS WITH BPRC

After “four amazing years with the BPRC family that I will never forget” Andi Makiola completed his PhD at Lincoln University in 2018. His thesis was titled “Characterising plant pathogen communities and their environmental drivers at a national scale”.

Andi’s research led directly to his new postdoctoral role at INRA (Institut national de la recherche agronomique), France.

“In my thesis I used a method called next-generation sequencing (metabarcoding) to detect plant pathogens across New Zealand and study what drives them at large scale,” he says. “In my new role, I am finding potential biocontrol agents using artificial intelligence.

“In my PhD I was involved in a lot of different things from sampling in the field, molecular work in the lab, bioinformatics and large data analysis in front of a computer.

“Learning multiple skills is becoming more and more important in a world where most of the cool science happens at the interface with other disciplines.”
WELL-PREPARED FOR SCIENCE CAREER

Soon after Kai Lewis graduated from Lincoln University with a Master of Science in 2018, he was hired by Plant & Food Research (PFR) in Auckland as a research associate.

Kai’s thesis, “Characterising the growth response and pathogenicity of *Phytophthora agathidicida* in soils from contrasting land uses”, made the news, with research showing that pine forests and pastoral land might harbour the pathogen responsible for kauri dieback.

“My MSc in soil pathology prepared me well for my role as a research associate, especially through developing laboratory techniques I use everyday.

“As well, the analytical skills I honed at BPRC have let me grow as a researcher.”

In particular, he says he is enjoying increasing his knowledge of the statistical program R.

“This is particularly relevant given the current excitement around artificial intelligence and machine learning. For instance, in my team we’re using machine-learning algorithms to classify disease images of grapevines and streamline the process of characterising disease distributions within a vineyard.”

NEW SPECIES DISCOVERED DURING PhD

Francesco Martoni will graduate from Lincoln University in May, having completed his PhD in entomology in May 2018.

He is now a research scientist with the Government of Victoria, Australia, in the Agriculture Victoria research division.

“This postdoc position is a perfect continuation of my PhD,” says Francesco. “My thesis aimed to study the diversity of New Zealand psyllids and the bacteria they vectored. I am now working on molecular methods to identify pest insects, using high-throughput DNA sequencing technologies.

“I have been submitting and publishing a number of articles as direct outputs of my PhD thesis. I am extremely proud I could record more than 20 new species of psyllids, and two of them (hopefully) will be published soon.”

Francesco says he loved his time at the Centre. “Doing my PhD was one of the best choices of my life.”

WAGING WAR ON WILDING PINES

In 2018 Rowan Sprague submitted her PhD at Lincoln University, with her thesis on “The scaling of conifer invasions in New Zealand”.

She then walked straight into a role as co-ordinator of the New Zealand Wilding Conifer Trust, hosted by Environment Canterbury.

“The Wilding Conifer Trust seeks to better connect all of the organisations involved in wilding conifer management and research,” says Rowan.

“As co-ordinator, I am responsible for communicating between community trusts, regional councils, and central government agencies. I am also working on connecting the findings in research to applications in management.”

Rowan says the knowledge she gained during her PhD has proved invaluable in her new role. “My PhD gave me a solid understanding of the biology of wilding conifers as well as some of the organisations involved in wilding conifer work.”

See also Spotting wilding pines from space, p21.
AWARDS AND ACHIEVEMENTS

Dr David Winter, a postdoctoral research fellow based at Massey University, Palmerston North, was awarded a $300,000 Marsden Fast Start grant for his research project “Treasure from the junk pile. Do transposable elements drive the evolution of gene expression?” He was also awarded a Young Investigator Travel Award to attend the Society for Molecular Biology & Evolution annual meeting in Yokohama, Japan, in July 2018. He was invited by the organising committee to give a talk at the meeting on “The contribution of transposable elements to the regulation of genes underlying symbiosis in Epichloë”.

Dr Warwick Allen (Lincoln University) was awarded a Hutton Fund research grant from the Royal Society of New Zealand, for work on “Incorporating indirect interactions into the invasion framework: advancing from pattern to process”.

PhD student Marion Schoof (AgResearch, Lincoln University) won third prize in the student presentation category at the Society for Invertebrate Pathology annual meeting on the Gold Coast in August.

Lincoln PhD student Karla Lopez received Catalyst Fund support to attend Lund University, Sweden, for a Catalyst: Seeding workshop. “The main topic and discussion was centred around vision in pest insects, focused especially on thrips, which is the topic of my PhD research,” says Karla. “I had a unique opportunity to learn and discuss my research project and get some very nice feedback from a great group of scientists.”

Assoc Prof Matt Templeton was part of the Plant & Food Research team of more than 100 scientists that won the 2017 Prime Minister’s Science Prize, for their work in reacting to the arrival of Psa. It’s a major prize, for significant teamwork, helping a major export industry overcome a game-changing threat. He was also part of a three-person team to win a $939,000 Marsden Fund award for a project titled “Excuse me, can you show me the way? Microbial chemotaxis and survival in the phyllosphere.”

Assoc Prof Matt Templeton

Marion Schoof

Prof Steve Wratten of Lincoln University was appointed a trustee of the Brian Mason Scientific & Technical Trust. He was also awarded the 2017 Lincoln University Excellence in Teaching Award, in the category of Postgraduate Research Supervision, and won a James Cook Research Fellowship from Royal Society Te Apārangi to study threats to bee populations and their pollination efficacy.
Dr Amanda Black, a Principal Investigator with the BPRC based at Lincoln University, won the AsureQuality Emerging Leader Award in the New Zealand Biosecurity Awards. Her citation says she has “not only been a leading scientist in the biosecurity space, she has also been a voice for nature, making sure that the systems for biosecurity improve”.

Lincoln PhD student Dilani Hettiarachchi received a 2018 International Society of Chemical Ecology Student Travel Award to attend its 2018 meeting in Budapest, Hungary, in August.

Prof Phil Hulme FRSNZ (Lincoln University) was selected as the Leonard Cockayne Lecturer for 2018. He gave his lecture, “Ornamental to detrimental: The invasion of New Zealand by non-native plants” in seven centres around New Zealand. He was also awarded the title of Distinguished Professor by Lincoln University and was named on the list of highly cited researchers for 2018.

Assoc Prof Peter Fineran, from the University of Otago, won the United Kingdom Microbiology Society’s 2019 Fleming Prize for outstanding early career research. Peter’s research aims to understand the interactions between mobile genetic elements such as bacteriophages and plasmids, and their bacterial hosts.

Prof Jason Tylianakis, of the University of Canterbury, was named a Fellow of the Royal Society Te Apārangi. His citation said he had “achieved a steep trajectory across many measures of research excellence in the area of how environmental changes affect interactions between species and their contribution to ecosystem functioning”. He was also recognised in the Clarivate Analytics list of highly cited researchers for 2018 – one of only 14 in New Zealand.

Prof Murray Cox of Massey University was part of a five-person team, spanning New Zealand and the United States, to win a $929,000 Marsden Fund award. The team is led by Dr Jennifer Tate, also of Massey University, and the project is titled “Getting the balance right: how do allopolyploids successfully integrate interspecific nuclear and cytoplasmic genomes?”

Prof Barry Scott (Massey University) is part of a three-person team given a $934,000 Marsden Fund award. The team is led by Prof Emily Parker of Victoria University of Wellington, and the project is titled “Molecular basis of diterpene chemical diversity”.

The Royal Society Te Apārangi awarded Dr Jonathan Tonkin, University of Canterbury, a Rutherford Discovery Fellowship for research entitled: “Rethinking ecological networks in changing environments”.

Prof Jason Tylianakis

Prof Amanda Black

Prof Phil Hulme FRSNZ

Prof Barry Scott

Dr Amanda Black

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Lincoln PhD student Sundar Tiwari won the “Clean and green” prize at the Lincoln University Postgraduate Conference for his oral presentation on “Trap cropping for the wheat bug to minimise ecosystem disservices from prophylactic pesticide use”.

University of Canterbury PhD candidate Ralph Wainer won the Ross Beever Memorial Mycological Award from the Fungal Network of New Zealand.

Dr Hossein Alizadeh and Prof John Hampton, both of Lincoln University, were awarded gold status by MBIE for the annual report of their project, “Supressing urea-N wastage using a bio-inoculant”.

The Next Generation Biopesticides MBIE programme, led by Dr Maureen O’Callaghan (AgResearch) and involving BPRC researchers from AgResearch, Plant & Food Research and Lincoln University, was awarded gold status for its annual report.

Dr Barbara Barratt, principal scientist at AgResearch, was awarded the New Zealand Plant Protection Medal for exceptional contributions to plant protection.

Aroa Rey Campa, a PhD student at the University of Otago, was awarded the top poster prize in the Department of Microbiology & Immunology, University of Otago Research Celebration.

Lincoln University PhD student Fabiola Padilla Arizmendi was awarded the best poster presentation at the 15th International Trichoderma & Gliocladium Workshop in Salamanca, Spain.

SCHOLARSHIPS

Lincoln University honours student Joel Faulkner, won one of the first two Seed Industry Research Centre scholarships to help fund his research of factors affecting pollination.

The New Zealand Plant Protection Society awarded Lincoln University PhD candidate Thomas Carlin the Dan Watkins Scholarship in Weed Science.
GOVERNANCE

In May we welcomed Richard Blaikie (University of Otago), Jessie Chan-Dorman (independent), and Philippa Stevens (Plant & Food Research) on to the Board.

Former BPRC director Alison Stewart (Scion) resigned from the Board in February and was replaced by Lindsay Bulman, of Scion.

After 11 years on the Board, frequently as acting chair, Barry O’Neil (independent) stepped down in June 2018.

At the end of 2018, Gail Tipa (independent) stepped down after four years on the Board.

ARRIVALS

Dr Sarah Wyse joined the Centre, based at Lincoln University, to work with Prof Phil Hulme on the winning against wildings project. She was previously based at the Royal Botanic Gardens, Kew, where she worked at the Millennium Seed Bank in West Sussex to model seed traits and seed behaviour.

Dr Baojun Wu has joined the Centre as a postdoctoral research fellow, based at Massey University, to work on genome evolution and speciation of Epichloë genus. His research interests include immune systems, fungal genomes, mitochondrial genomes, new genes, and transposons.

Dr Xiaoben Jiang is a microbial ecologist who has joined the Centre as a postdoctoral research scientist, based at Scion. He is investigating how different plant species affect the microbiome around their roots (rhizosphere ecology).

Dr Jonathan Tonkin joined the Centre as a postdoctoral fellow, based at the University of Canterbury, to work on Project 6: achieving bioprotection in New Zealand ecosystems. His research interests include understanding and predicting ecological network structure and dynamics, developing community-wide mechanistic models, and metacommunity dynamics in dendritic networks.

Dr Alexandra (Sasha) Gavryushkina joined the Centre as a postdoctoral fellow to work on Project 5, enhancing microbial-based biological control. Sasha has PhDs in computational biology (University of Auckland) and mathematics (Novosibirsk University, Russia), and is interested in bioinformatics, particularly in developing methods for phenotype-genotype association studies.

DEPARTURES

Dr Robert Hill, a former Principal Research Officer based at Lincoln University, retired in March after 10 years with the Centre. Robert pioneered the use of the root endophyte Trichoderma to enhance plant vigour and reduce the incidence of disease.

Dr Michael Rostás arrived to take up his role as senior lecturer at Lincoln University in July 2010, “just in time for the full earthquake experience”, he says. In 2018 Michael moved to Göttingen in central Germany, to take up the position of Professor of Agricultural Entomology at the University of Göttingen.
Melanie Mark-Shadbolt has left after 10 years with the Centre, based at Lincoln University, most recently as Māori Research Development Manager Kairahi. She was instrumental in setting up Te Tira Whakamātaki, the Māori Biosecurity Network, and in engaging iwi in the battle against myrtle rust. In 2016 Te Tira Whakamātaki won the New Zealand Biosecurity Institute’s Innovation Award, and in 2017 it won MPI’s Māori Biosecurity Award. Melanie has taken a role as Director Māori for New Zealand’s Biological Heritage Science Challenge. She has also been appointed as Kaihautū – Chief Māori Advisor for the Ministry for the Environment.

After six years working as a research technician with the Centre at Lincoln University, Dr Jin-Hua Li left in 2018 to take up a role as postdoctoral research scientist at Lincoln Agritech, also based at Lincoln University.

After 5½ years with the Centre at Lincoln University, as a research technician and then postdoctoral fellow, Dr Nic Cummings has left to take up a permanent position as plant pathologist at AsureQuality, also based at Lincoln University.

GRADUATING STUDENTS

PhDs

Marona Capdevila graduated from Lincoln University. Her thesis was “Matching invasive species to invaded environments using climate, habitat and phylogeny”.

Priscila Freitas graduated from Lincoln University. Her thesis was “Crossing the species barrier: investigating vertical transmission of a fungal endophyte from tall fescue within a novel ryegrass association”.

Aimee McKinnon graduated from Lincoln University. Her thesis was “Interactions between isolates of the fungus Beauveria bassiana and Zea mays”.

Laura Nixon graduated from Lincoln University. Her thesis was “Identification of biogenic volatile organic compounds for improved border biosecurity”.

Marsha Ormskirk graduated from Lincoln University. Her thesis was “Brevibacillus laterosporus as a potential biocontrol agent of the diamondback moth and other insects”.

Nazanin Noorifar graduated from Massey University. Her thesis was “How does Epichloë festucae avoid the host defence response?”

Pavithra Ramakrishnan Coimbatore graduated from Lincoln University. Her thesis was “Understanding the molecular response of potato during infections with Pectobacterium”.

Maya Raad graduated from Lincoln University. Her thesis was “Plant-mediated interactions between the entomopathogenic fungus Beauveria bassiana, insect herbivores and a plant pathogen”.

Ursula Torres graduated from Lincoln University. Her thesis was “Quantitative and theoretical analysis of species distribution models for invasive species risk assessment and management”.

MScs

Jenny Brookes graduated with an MSc from Lincoln University. Her thesis was “Endophytes in maize (Zea mays) in New Zealand”.

Wesis Pus graduated with an MSc from Lincoln University. His thesis was “Plant-mediated effects of Trichoderma spp. and Beauveria bassiana isolates on insect and pathogen resistance”.

Marsha Ormskirk
2018 DIRECTORY

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Assoc Prof Paul Gardner | University of Canterbury/University of Otago
Prof Travis Glare | Lincoln University
Prof Stephen Goldson | AgResearch/Lincoln University
Dr Andrew Holyoake | Lincoln University
Prof Philip Hulme | Lincoln University
Dr Sarah Mansfield | AgResearch
Melanie Mark-Shadbolt | Lincoln University
Adjunct Assoc Prof Maureen O’Callaghan | AgResearch/Lincoln University
Prof Barry Scott | Massey University
Philippa Stevens | Plant & Food Research
Assoc Prof Matt Templeton | Plant & Food Research
Dr David Teulon | Plant & Food Research
Prof Steve Wratten | Lincoln University

OPERATIONAL MANAGEMENT GROUP
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Ashley Campbell | Lincoln University
Dianne Fyfe | Lincoln University
Dr Andrew Holyoake | Lincoln University
Kiri Hurunui | Lincoln University
Janine Johnson | Lincoln University
Brian Kwan | Lincoln University
Stuart Larsen | Lincoln University
Claire Tee | Lincoln University
Sandy Wilson | Lincoln University

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Melanie Mark-Shadbolt | Lincoln University

MĀORI CHAMPIONS – KAIHAUTŪ
Dr Nick Waipara | Auckland Regional Council/Plant & Food Research
Dr Nick Roskruge | Massey University
Dr Jamie Ataria | Lincoln University

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Dr Kieran Arthur | Plant & Food Research
Dr Jamie Ataria | Lincoln University
Dr Amanda Black | Lincoln University
Dr Simon Lambert | Lincoln University
Alby Marsh | Plant & Food Research
Dr Nick Roskruge | Massey University
Dr Nick Waipara | Plant & Food Research

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Dr Amanda Black | Lincoln University
Prof Leo Condron | Lincoln University
Prof Ian Dickie | Lincoln University/University of Canterbury
Prof Travis Glare | Lincoln University
Prof Stephen Goldson | AgResearch/Lincoln University
Prof Philip Hulme | Lincoln University
Prof Peter Lockhart | Massey University
Prof Barry Scott | Massey University
Assoc Prof Matt Templeton | Plant & Food Research/Auckland University
Prof Jason Tylianakis | University of Canterbury
Prof Steve Wratten | Lincoln University
**TEC-FUNDED ASSOCIATE INVESTIGATORS**

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<thead>
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<td>Aroa Rey Campa</td>
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<td>André Costan</td>
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**ALIGNED RESEARCHERS**

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<td>Dr Sue Zydenbos</td>
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**ALIGNED POSTDOCTORAL RESEARCH FELLOWS**
Dr Pranav Chettri | Massey University  
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Dr Peter Holder | Lincoln University  
Dr Marsha Ormskirk | Lincoln University  
Dr Abagail Durrant | Lincoln University  
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Dr Wadia Kandula | Lincoln University  
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John Marris | Lincoln University  
Norma Merrick | Lincoln University  
Dr Bionda Morelissen | Lincoln University  
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Tauseef Babar | Lincoln University  
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Dilani Kasundara Hettiarachchi | Lincoln University  
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Khan Mir Khan | Lincoln University  
Michal Kuchár | Lincoln University  
Karla Lopez | Lincoln University  
Andreas Makiola | Lincoln University  
Francesco Martoni | Lincoln University  
Nghia Thi Nguyen | Lincoln University  
Laura Nixon | Lincoln University  
Guillermo Nogueira Lopez | Lincoln University  
Marsha Ormskirk | Lincoln University  
Ryan Rayl | Lincoln University  
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Howard London | Lincoln University  
Thi Tam Huong Pham | Lincoln University  
Olivia Prouse | Lincoln University  
Wesis Pus | Lincoln University  
Abdullah Umar | Lincoln University

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Joel Faulkner | Lincoln University  
Erin Stroud | University of Auckland

**SUMMER SCHOLARS**
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Sarah Cairns  
Pauline Cervantes  
Georgia Steel  
Jerusha Brown  
Jodanne Aitken  
Marcus Shadbolt
SHARING KNOWLEDGE

Dr Lauren Waller, Postdoctoral Fellow, Lincoln University
2018 ENGAGEMENT AND OUTPUTS AT A GLANCE

**MEDIA**

- 162 Media articles & interviews
- 6 Newsletters published
- 21,364 users / 27,024 sessions

**SOCIAL MEDIA**

- 305 tweets
- 168.6K impressions
- 1489 followers
- 182 posts
- 5.9K highest post reach
- 389 followers

- 19 posts / 150 followers
OUT PUTS

52 Seminars

121 Journal articles

8 Books or book chapters

66 Conference presentations

372 collaborations

INTERNATIONAL

Argentina 3
Australia 13
Austria 9
Belgium 4
Brazil 2
Cambodia 1
Canada 9
Chile 1
China 15
Colombia 2
Costa Rica 1
Czech Republic 8
Denmark 1
Ecuador 2
Estonia 1
Ethiopia 2
Finland 1
France 13
Germany 24
Ghana 1
Greece 2
India 2
Indonesia 1
Iran 1
Ireland 2
Israel 2
Italy 10
Japan 6
Jordan 1
Kenya 2
Korea 2
Malaysia 2
New Zealand 12
Netherlands 3
Netherlands 1
Panama 1
Papua New Guinea 1
Poland 1
Portugal 2
Serbia 1
South Africa 4
Spain 3
Sri Lanka 2
Switzerland 9
Thailand 2
The Netherlands 2
The Philippines 5
UK 22
Uruguay 1
USA 23
Vietnam 2
A YEAR OF ENGAGEMENT AND ATTENTION

2018 was a busy year for the Centre in terms of conferences, seminars, and media engagement. In the following pages we highlight some of the events and stories that put our work and purpose in front of industry, academics, and the public during the year.

KAURI DIEBACK DOMINATES MAINSTREAM MEDIA

With brown marmorated stink bug, climate change, and kauri dieback creating headlines in mainstream media during 2018, there was seldom a week when the Bio-Protection Research Centre wasn’t in the news.

In January Prof Travis Glare made a splash in the New Zealand Herald’s “50 questions about our environment” series, answering questions about biosecurity. Travis correctly predicted that brown marmorated stink bug (BMSB) would become a major concern.

In late February, news that 10,000-12,000 cars had been turned away from the border because of contamination with BMSB led to a flurry of media activity. Senior lecturer Dr Michael Rostás featured in a Science Media Centre expert question and answer article on the pest, and over the next month was quoted in publications as diverse as the New Zealand Herald, Newstalk ZB, and the Westport News.

The next big news story for the Centre came with a paper outlining how climate change could result in more disease for New Zealand crops, but could reduce the severity of some diseases such as red needle cast of radiata pine. A media release quoting lead researcher Dr Steve Wakelin resulted in stories in the New Zealand Herald, and several provincial newspapers.

But the biggest story in mainstream media during the year was kauri dieback. It began with interviews of Dr Amanda Black and Dr Nick Waipara on Morning Report in July 3, suggesting the Waipoua Forest was at a tipping point and Tane Mahuta could soon be infected.

The topic stayed at the top of the news agenda for two months, boosted by research from former Masters student Kai Lewis raising the possibility that Phytophthora agathidicida could survive in pine forest and pasture soil.

And New Zealand’s most iconic tree also featured in the last big mainstream media story to highlight the Centre in 2018.

Dr Sarah Wyse’s research revealed the seeds of kauri, totara, rimu, and several other native trees were not viable in traditional seed banks and could not be saved this way. Instead, she said in a comment that was picked up by several media, “If we are serious about wanting to save our unique trees, we need to do everything we can to save them in their natural environment, because other methods may simply not work.”
SHARING OUR KNOWLEDGE WITH PRIMARY PRODUCERS

Ensuring primary producers know about the Centre’s research and its implications for their industry, is an important goal of the Centre’s communications strategy.

In 2018, we specifically focused on gaining coverage in industry media, in titles ranging from Farmers Weekly and The Country, to niche titles such as Grower2Grower, NZ Grower, and Rural Contractor.

Our research also featured on specialist television programmes such as Rural Delivery and Forest Call.

Submitted pieces explaining the threats facing our productive sector and native environment, and long-term solutions the Centre was working towards, were well-received.

Submitted coverage of a visit by the board of TomatoesNZ was given a double-page spread in NZ Grower in April, under the headline “Industry must wean off sprays and on to biocontrol”.

Director Prof Travis Glare helped to raise the profile of bioprotection among farmers, with pieces in Farmers Weekly (“Only science can combat pests”) and The Country (“What next after the EU neonicitinoid ban?”). As well, Prof Steve Wratten wrote a piece on regenerative agriculture published in NZ Farmers Weekly (“It’s time to change farming”).

Other industry titles to publish submitted pieces were Ravensdown’s magazine Ground Effect (“Ahead of the game with the Bio-Protection Research Centre”) and New Zealand Tree Grower (“Trichoderma research shows great promise”).

SOCIALISING THE SCIENCE

In 2018 the Centre made a concerted push into social media, to engage a new audience and familiarise more people with the work our scientists are doing.

We have always been active on Twitter – a good channel for interacting with scientists – but in 2018 we branched out into media that are popular with a younger and more diverse demographic.

In January we started a Facebook page (@BioProtectionNZ). Our most popular posts, each reaching almost 6000 people, both relate to the big news story of the year – kauri dieback. One, in July, advertised a scholarship to research kauri dieback; the other in October, congratulated Drs Amanda Black and Nick Waipara for reaching the finals of the New Zealand Biosecurity Awards.

In August, we moved on to Instagram (bioprotection.nz), and by the end of the year had 160 followers. We are still building our audience – focusing on eye-catching photos of plants and insects – and count farmers and scientists among our followers. Our most popular image in 2018 was a bee pollinating a harakeke flower (above, taken by Wadia Kandula).

At the end of the year we opened a LinkedIn business page (Bio-Protection Research Centre).
After the board of TomatoesNZ visited the Bio-Protection Research Centre in 2018, TNZ chair Alasdair MacLeod called for the industry to move away from sprays and start using biocontrol methods to manage pests.

“Our industry is currently worth about $120 million, and our target is to get to $200 million,” Mr MacLeod said.

“The reality is that the only way we can ever grow that value is through exporting a premium product. The people who pay for a premium product demand organic, GMO-free, and spray-free. This is the way we have to go.”

Prof Steve Wratten, Principal Investigator with the BPRC, told the TNZ board many people believed New Zealand needed to import biocontrol agents. But many agents were already here and had worked well in greenhouses before the arrival of the tomato potato psyllid (TPP) in New Zealand in 2006, when spraying became the norm.

Hearing that it should be possible to find whitefly predators within New Zealand, rather than importing them, was a “real ah-ha moment” for most of the board, said Mr MacLeod. “If there wasn’t any biocontrol of whitefly, for example, there would be whitefly everywhere.”

Dr Charles ‘Merf’ Merfield, of the Future Farming Centre, also presented to TNZ, saying New Zealand’s industry had relied for too long on chemical control of horticultural pests.

“Chemicals are becoming less effective because of over-use and increased pest resistance, and there are very few new chemical controls coming through,” Dr Merfield said. “The future of pest management lies in physical, ecological, and biological control.”

Growers could encourage the natural enemies of plant pests, so they worked more effectively, for longer, said Prof Wratten.

In vineyards, planting buckwheat between the rows of vines created a beneficial environment for predatory insects by providing them with shelter, nectar, alternative food, and pollen.

“A parasitic wasp that lives for just three days on water alone lives for 42 to 43 days when it has access to buckwheat flowers,” Prof Wratten said. Other parasitic wasps, including the TPP parasite Tamarixia, also thrived on buckwheat, so planting it with crops would help to naturally control horticultural pests.

TNZ general manager Helen Barnes said the board was rethinking its research focus after the presentations. “We weren’t aware of the depth and range of research the scientists were doing.”

Following the visit, TNZ has funded a PhD research scholarship to develop further biological control of TPP, with research beginning in 2019.
BACK BY POPULAR DEMAND

New Zealanders are hungry to know more about what happens when exotic garden plants jump the garden fence, judging by reaction to Prof Philip Hulme’s Leonard Cockayne Lecture series.

Phil’s lecture, sponsored through an award from the Royal Society Te Apārangi, was titled “Ornamental to detrimental: The invasion of New Zealand by non-native plants”. It was originally scheduled for five locations (Palmerston North, Napier, Christchurch, Wellington, and Nelson), but public demand means four more venues were added in 2018, with another three at the beginning of 2019.

“There have been about 100 people at each event to date, and there’s a surprising amount of interest in the science underpinning weed problems in New Zealand,” Phil says.

“As well as many members of the public, I’ve had the chance to discuss my work with staff from Regional Councils, DOC and MPI.”

As a result of his award, Phil gave an in-depth interview to Wallace Chapman on RNZ’s Sunday Morning programme in May.

Given the calibre of past recipients, Phil says it was humbling to receive the Leonard Cockayne Lecture Award, and it was a great way to reach people who would not normally hear of the Centre. The award has been presented every three years since 1965.

CONFERENCE-GOERS GET DOUBLE-DOSE OF BIOCONTROL

Biocontrol was high on the agenda for around 400 delegates at Horticulture New Zealand’s annual conference, held at the Air Force Museum, in Christchurch in July.

The Bio-Protection Research Centre’s Prof Steve Wratten (above, far left) took part in a panel discussion on “The post-pesticide age”, and also gave a keynote speech on “Advanced bioprotection in an age of agricultural and horticultural volatility”.

During the panel discussion – also featuring Dr Alison Stewart, Foundation for Arable Research, Dr Charles Merfield, Future Farming Centre, and Robbie McCormick, Mr Apple – Steve discussed research into using predators such as green and brown lacewings as biocontrol agents in glasshouses.

“In the weeks after this presentation we had many follow-ups, including TomatoesNZ deciding to fund a PhD on biocontrol of glasshouse pests.”
RESEARCH OUTPUTS 2018

(*) TEC CORE-funded research

REFEREED JOURNAL ARTICLES


Brown SD (2018). Redescription of Brachylonus punctatus White. 1846 (Coleoptera: Curculionidae: Entiminae) with synonyms and lectotype designations. Zootaxa 4359: 432-442. DOI: 10.11646/zootaxa.4359.3.8


**REFEREED BOOKS AND BOOK CHAPTERS**


## FINANCIALS 2018

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</tr>
<tr>
<td>Postgraduate students</td>
<td>706</td>
</tr>
<tr>
<td>Equipment depreciation/rental</td>
<td>149</td>
</tr>
<tr>
<td>Subcontractor(s) specified</td>
<td>110</td>
</tr>
<tr>
<td><strong>Total Other Costs</strong></td>
<td><strong>3006</strong></td>
</tr>
<tr>
<td><strong>Total Expenditure</strong></td>
<td><strong>5057</strong></td>
</tr>
<tr>
<td>Net Surplus/(Deficit)</td>
<td>784</td>
</tr>
<tr>
<td>Other Aligned Funding</td>
<td>5419</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

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