Modelling reveals economic value of bioprotection

A recent report from the Agribusiness & Economics Research Unit (AERU) at Lincoln University has shown the high economic costs of pest and weed invasions for New Zealand’s primary industries, and the benefits of using bioprotection strategies to reduce these losses. The AERU is an independent provider of applied economic and sociological knowledge.

In 2012, New Zealand’s income from the agricultural sector was NZ$9,400 million, which is about 6.4% of the country’s gross domestic product (GDP). Pests, diseases and weeds are major threats to these primary industries. Ideally, pre-border inspections will prevent biosecurity incursions, but if a pest does establish farmers may need multiple strategies to mitigate expensive losses.

Researchers in the AERU have developed a model that can estimate the economic impact of plant pests, diseases or weeds. This model is based on data from the Lincoln Trade and Environment Model and the Ministry for Primary Industries farm monitoring reports. Data from these sources has been used to predict economic outputs until 2030.

“We began with an economic model based on forecasts of profits in the agricultural sector,” explains researcher John Saunders. “The model was then used to map the outcomes of different pest invasion scenarios. This involved extensive literature reviews and consultation with science experts in agricultural pests and invasion biology.”

The model has shown that bioprotection strategies can significantly reduce the financial losses of pest invasions, and are more effective and feasible than less sustainable or less environmentally-friendly alternatives like pesticides or herbicides.

The AERU’s economic model has been applied to different invasion scenarios, which represent a range of current and potential challenges to New Zealand’s pastoral agriculture sector. These were the insect pests; clover root weevil and glassy-winged sharpshooter, and the important weed, giant buttercup.

The clover root weevil, for example, was first discovered in New Zealand in 1996. Weevil populations are already established in the North Island and are now spreading throughout the country. The weevil decimates clover, reducing pasture dry matter available for grazing animals and removing the clover nitrogen fixing benefits. The AERU has estimated that the weevil will cost the dairy, beef and sheep industries NZ$604 million per year over the next 18 years, if spread of the insect is not controlled. Establishing an Irish wasp as a biological control agent during the period of modelling was estimated to save between NZ$400 and NZ$500 million per year in losses, depending upon the wasp’s overall effectiveness. Applying nitrogen to mitigate the effects of the weevil was estimated to save about NZ$300 million per year, but this strategy would be undesirable because of the risks of contaminating groundwater with excess nitrogen.

The giant buttercup is present in almost half the dairying regions in New Zealand. This weed reduces dry matter content of pasture as cattle find it unpalatable and avoid eating it. The economic model estimates that if the giant buttercup was present it could cost the dairying industry up to a billion dollars per year. The model predicts that using herbicide could mitigate 25% of this lost revenue; whereas the biocontrol agent, a fungus called *Sclerotinia sclerotiorum*, could mitigate over 70% of the loss.

The final scenario explored by the AERU researchers was an invasion by the glassy-winged sharpshooter (GWSS), a Mexican leafhopper insect that has causes widespread damage to citrus and vines through feeding and the spread of Pierce’s disease. The GWSS is not present in New Zealand, but since 2000 has spread to Hawaii and the Cook Islands. The economic model estimates that if the GWSS established in the North Island it would cause a steady decline in viticulture profits, costing up to NZ$5 million per year. 85% of these effects could be mitigated by the biocontrol agent *Gonatocerus ashmeadi*, which has been effective at reducing sharpshooter numbers in other countries.


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www.bioprotection.org.nz
From the Director

As the new Director of the Bio-Protection Research Centre, I have taken over the role so ably filled by Dr James Buwalda at a very exciting time. Dr Buwalda has developed a new mission statement for the Centre: “The development of innovative biological strategies, through world-leading research, to protect New Zealand from pest, pathogen and weed threats,” and we are now determining the future research that needs to be undertaken to realise this mission.

We have conducted a series of workshops and meetings with senior researchers to develop three interrelated themes for our research. These are: 1) exploiting the molecular basis of resistance to pathogens; 2) improving the impact and durability of biological controls; and 3) anticipating and managing invasion tipping points. These themes are the basis for our application to the Tertiary Education Commission for continued funding as a Centre of Research Excellence.

The Centre has always drawn strength from the synergies between its partner research organisations. Combining researchers, institutional knowledge and infrastructure at Lincoln University, Massey University, AgResearch and Plant & Food Research has led to excellent science aligned with New Zealand’s bioprotection needs. The Centre’s partnerships will be further strengthened when we welcome a new partner organisation – Scion (formerly the Forest Research Institute) – in 2014.

I have been associated with the Centre since its inception in 2003, as a former board member and as a researcher. It is a pleasure to take up the Director’s role and to help support our staff and students in their endeavours to find solutions to New Zealand’s plant protection issues.

Bringing back the bees: a citizen science project

A new initiative between the Bio-Protection Research Centre and Kings Seeds is encouraging local communities to understand the value of bioprotection and to help boost bee numbers in New Zealand.

Worldwide bee populations are declining because of disease, modern agricultural practices and the indiscriminate use of insecticides. This has profound implications for our food supply, with two-thirds of our food plants depending upon insect pollination.

The idea to encourage communities to help bring back the bees came about when Arthur Baysting, an Auckland-based writer and comedian, suggested exploiting Canterbury’s post-earthquake red zone areas as bee sanctuaries. He contacted Prof Steve Wratten and Dr Roddy Hale at Lincoln University, who used their research and extensive knowledge of insects and floral resources to assemble a list of annual flowering plants that were high in nectar and pollen and favoured by bees.

“This ‘citizen-science’ project builds on work we are doing in LENScience with the Liggins Institute at the University of Auckland”, explains Prof Wratten. “That project, called ‘Blue 2B Green’ has developed work packages for schools to show how appropriately added biodiversity can benefit our valued bees, and also butterflies and pest-consuming beneficial insects such as ladybirds. This uses kinesthetic learning methods to bring practical biodiversity awareness to school students and adults.”

Bee-attracting plants have been produced as a seed mix with help from Gerard Martin at Kings Seeds. He sourced easy-to-grow seeds that were suitable for New Zealand conditions, and the Wildflower Pollinator Blend was then created. It is a mix of rudbeckia, thyme, red clover, phacelia, echium, salvia, cornflower and European poppy, which is designed to produce plants that provide bees with pollen and nectar throughout the summer months.

The Bringing Back the Bees initiative advocates planting bee-attracting flowers, providing nest boxes for bumble bees and stopping spraying of insecticides. The initiative has high-profile support from “The Bugman”, Ruud Kleinpaste, and was promoted in his recent talk at TEDxChristchurch 2013 and in his radio programmes.

Wildflower Pollinator Blend is available for purchase online from Kings Seeds (www.kingsseeds.co.nz) or at local Farmers’ Markets in Canterbury and Wellington.

LENScience bioprotection teaching resources are available online at: http://www.lenscience.auckland.ac.nz/uoa/home/about/teaching-and-learning-resources/bioprotection-modules

For more information
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Molecular analysis of endangered land snail diet

A recent study published in *PLOS One* by Dr Stéphane Boyer of the Bio-Protection Research Centre, Lincoln University represents a significant advance in molecular analysis of predation. Using next-generation sequencing, Dr Boyer analysed the diet of *Powelliphanta augusta*, a highly endangered, carnivorous land snail endemic to New Zealand.

His study provides detailed analysis of the snail’s diet, which will inform conservation programmes and ensure long-term survival of relocated and captive snail populations. Although previous studies had shown that *P. augusta* almost exclusively feeds on earthworms, consuming them like spaghetti, the identity of the predated species as well as their relative diet contributions were previously unknown.

Using a new molecular diet analysis protocol, Dr Boyer amplified and sequenced DNA fragments from *P. augusta* faecal samples. He identified 16 different species of earthworm in the faeces of 35 snails. These results show that *P. augusta* can feed on a wide variety of earthworm species, since all but two of the species found in the snail’s distribution area were detected. Moreover, further studies showed that the abundance of the various earthworm species in the environment was similar to the proportion of each species in the snail. This suggests that the snails forage randomly through the litter and predate any earthworms they encounter.

Such non-specificity has important implications for the conservation management of *P. augusta*. The original habitat of the snail is on the western scarp of the Stockton Plateau, on the northern West Coast of the South Island. Most of this habitat has been lost to open-cast coal mining, and over 6000 snails were hand-collected to allow mining to continue. These were either relocated in 2006 to adjacent undisturbed areas outside the planned mine area, or kept in captivity for re-introduction once the original site has been rehabilitated. This study has provided conservation workers with information to guide the choice of relocation areas, the feeding protocols for captive snails and the ecological restoration of their original habitat.

More generally, Dr Boyer’s molecular analysis protocol will be very useful for studying diets of other vertebrate or invertebrate species, especially endangered species, because it does not harm or disturb the animals being investigated.

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Identifying soil microbial genes that suppress plant disease

Centre PhD student Bryony Dignam has been collaborating with the Institute for Environmental Genomics, University of Oklahoma to build a novel system that can detect genes involved in suppressing soil-borne plant pathogens.

Improving soil management to reduce plant disease is a key goal for sustainable agriculture. Plant diseases can be suppressed by the actions of beneficial soil microbes, which produce antibiotics and lytic enzymes that can inhibit the growth of pathogenic organisms. Research has shown that genes involved in disease suppression are genetically conserved across species.

Bryony has been working with scientists in Oklahoma to expand their ‘GeoChip’ microarray system to identify genes involved in disease suppression. The GeoChip can simultaneously detect hundreds of gene families involved in key ecosystem processes mediated by microbes, such as nutrient cycling or degradation of organic pesticides. Bryony’s research has added an extra suite of probes to detect genes that may be involved in suppression of soil-borne plant pathogens. She is now using this system to understand how widespread disease-suppression genes are in New Zealand’s pastoral systems, and whether their abundances are influenced by farm management practices.

Bryony’s work may lead to new opportunities to manage the functional ecology of New Zealand’s agricultural soils, which will make them naturally more resistant and resilient to pests and diseases.

Byrny is working with Prof Leo Condron at Lincoln University, and Adjunct Assoc Prof Maureen O’Callaghan and Dr Steve Wakelin at AgResearch. She also has guidance from Profs George Kowalchuk, Netherlands Institute of Ecology and Jos Raaijmakers, Wageningen UPI, who are experts in microbial ecology and disease suppression.

For more information:
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Awards and Achievements

**Prof Richard Falloon** was elected Fellow of the International Society for Plant Pathology (ISPP) at the 10th International Congress of Plant Pathology, in Beijing, China (August 25-30). The fellowship recognised his contributions to research on diseases of forage, arable and vegetable crops, and fundamental studies of plant pathogens.

**Prof Stephen Goldson** has been named an Officer of the New Zealand Order of Merit (ONZM) in the 2014 New Year Honours List.

**Prof Philip Hulme** has been appointed to the Ministry for Primary Industries Biosecurity Advisory Committee. The role of the committee is to provide the Minister with advice on future trends, risks and issues that may impact on the performance of the biosecurity system, and to identify opportunities for improvement.

**Dr Michael Rostás** has been awarded a Habilitation degree in Ecology from the University of Würzburg, Germany in October 2013.

**Prof Steve Wratten** has been elected as Chair of the Open Polytechnic’s Advisory Group for their Bachelor of Applied Science degree. He has also been appointed as a Visiting Professor at Northwest University, Shaanxi, China.

**Dr Kirstin Wright (née McLean)** was awarded a Graduate Certificate in Science Innovation and Entrepreneurship with distinction from the University of Canterbury in December 2013.

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**Prof Philip Hulme elected Fellow of the Royal Society of NZ**

Prof Philip Hulme is among thirteen of New Zealand’s top researchers and scholars who were recently elected as Fellows of the Royal Society of New Zealand.

Prof Hulme was recognised for his scholarship and scientific achievements that have significantly progressed global understanding of the causes and consequences of biological invasions.

“This is a highly prestigious recognition of his research ability”, says Lincoln University’s Vice-Chancellor Dr Andrew West. “The election also recognises the excellence of his personal scientific output and that of his team within the Bio-Protection Research Centre. Moreover, Professor Hulme was elected immediately upon his name being submitted to the Royal Society. Such immediacy is unusual and a reflection of the high esteem in which he is held by his scientific peers.”

The Royal Society of New Zealand now has 391 Fellows and 60 Honorary Fellows. Fellows are involved in providing expert advice, promoting best and innovative research practice and disseminating information on the sciences and humanities.

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**Prof Robert Costanza appointed Distinguished Visiting Professor**

Prof Robert Costanza has been appointed as a Distinguished Visiting Professor to Lincoln University through his affiliation with the Bio-Protection Research Centre.

Prof Costanza is an internationally renowned researcher in ecological economics. His research integrates nature’s benefits with human wellbeing to provide guidance on managing world resources for government policymakers. He is currently Professor and Chair in Public Policy at The Australian National University, Canberra.

As Distinguished Visiting Professor, Prof Costanza will spend two weeks each year in the Centre and engage with staff and students on ecosystem services and agriculture.

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[www.bioprotection.org.nz](http://www.bioprotection.org.nz)
Professor of Invasion Ecology appointed

In September 2013, Dr Ian Dickie was appointed as Professor of Invasion Ecology at the Bio-Protection Research Centre – he will be based at Lincoln University.

Prof Dickie is an ecologist with a research background in plant-soil interactions and their role in ecosystem stability and transitions. He specialises in mycorrhizas – symbiotic associations between fungi and plants – and their influence on plant invasions.

“My group will work on weed invasions at the interface of productive and conservation land,” says Prof Dickie. “The focus will be on major forestry species, like Douglas-fir, gum and pine, and invasive species, like broom. We will also investigate how plants can modify soil nutrient cycling in ways that may make ecosystems more or less resistant to invasions.” His work will contribute to the Centre’s Dynamics of Biological Invasions research theme, which is led by Prof Philip Hulme.

Marsden grant to study plant-fungus interactions

Bio-Protection Research Centre research fellow Dr Carla Eaton has been awarded a $300,000 Marsden Fast-Start grant to find out how interactions between plants and fungi are controlled.

Interactions between fungi and plants are common in nature. They can be beneficial, where both fungus and plant benefit, or detrimental, where the fungus damages the plant. “My research will look at the mechanisms that control plant-fungal interactions. We’re going to compare signalling between a ‘good’ interaction and a ‘bad’ or pathogenic interaction. We want to find out how genetically similar fungi can have such different effects,” says Dr Eaton.

The study will use two model fungi: the beneficial endophyte of ryegrass, Epichloë festucae and the pathogenic rice blast fungus Magnaporthe oryzae. As part of her Marsden project, Dr Eaton will collaborate with Professors Nicholas Talbot and Sarah Gurr at the University of Exeter, UK, who are experts with the rice blast pathogen.

PhD student examines historic beetle collections

In August 2013, Centre PhD student Samuel Brown travelled to the UK to study weevil type specimens at the Natural History Museum in London. This trip is a crucial component of Sam’s thesis — it will help him revise the taxonomy of the New Zealand grassland weevil genus Irenimus and accurately identify new species.

New Zealand has more than 1500 species of plant-feeding weevils, and most of these are unique to this country. In the Irenimus genus there are 50 known species, and a few of these are significant pasture pests. To date, research into the impacts, management, distribution and evolution of these endemic weevils has been hindered by inability to accurately identify species. Sam’s PhD research will address these issues.

At the Natural History Museum, Sam viewed the extensive beetle collections of Thomas Broun. Broun was a farmer, teacher and avid entomologist who migrated from Scotland to New Zealand in 1863, and collected and described more than 4000 New Zealand beetle species.

Broun’s type specimens and written descriptions are the foundation for identifying all New Zealand beetles. However, his original work is now outdated and often difficult to interpret because of the lack of illustrations. Viewing Broun’s type specimens has helped Sam to verify the original identifications of Irenimus weevils, and ensure that the identification of current and future species is consistent.

“I was able to discuss weevil and beetle classification and taxonomy with world-renowned researchers,” says Sam. “This was a great opportunity to feel part of the global beetle research community”.

While in Europe, Sam also visited Muséum National d’Histoire Naturelle in Paris, France and the Staatliches Museum für Naturkunde in Karlsruhe, Germany. This trip was funded by a grant from the Spragg Agricultural Research and Development Award.
Postgraduate student profiles

**Jenny Brookes**
Title: Endophytic microbes in Pinus radiata.
Jenny has completed her BSc at Lincoln University with a double major in Bioprotection and Biosecurity, and Conservation and Ecology. For her Master's degree, she will study the endophytic microorganisms present in the roots of pine trees from different geographical areas within New Zealand.
Supervisor: Prof Travis Glare (Lincoln University)
Associate supervisor: Dr Michael Rostás (Lincoln University)

**Steven Cordwell**
Title: Network analysis of post-borer pest spread.
Steven has a BSc (Hons) and a BA from the University of Queensland, Australia. His PhD project aims to develop network models for generalised pathogens/pests under different types of networks and then use the models to evaluate a set of strategies for sampling invasive movement under increasing limits on sampling resources. Steven's project will interrogate existing national statistics and end-user information to build a better picture of the connectedness of crops across Australia and New Zealand.
Supervisors: Prof Philip Hulme (Lincoln University) and Dr Michael Rostás (Lincoln University)

**Tina Q. Chen**
Title: Analysis of the establishment failure of plant pests to better inform the post-risk assessment process.
Tina has a BSc (Hons) in Environmental Plant Biotechnology from University College, Cork, Ireland, and an MPhil in Integrated Pest Management from Imperial College, London. Her PhD research will use artificial neural networks to investigate factors that determine establishment failure of selected exotic plant pests in Australia and New Zealand. Through his research, Tina is interested in enhancing and improving the methodology, data and tools of the pest risk assessment process.
Supervisor: Assoc Prof Sue Worner (Lincoln University)
Associate supervisor: Adjunct Prof David Toulet (Plant & Food Research)
External co-supervisor: Dr Dean Pani (CSIRO, Australia)

**Federico Rikas**
Title: Development of a seed coating based on entomopathogenic fungi (Metarhizium spp. or Beauveria spp.) for protection of crops against plant diseases and insect pests.
Federico has a BSc in Biochemistry and MSc in Microbiology (Hons) from the Universidad del Republica, Uruguay. For his PhD, Federico will be developing a seed coating based on entomopathogenic (insect-killing) fungi. If successful, this strategy will help develop novel opportunities for seed technology and the delivery of biocontrol agents for crop protection.
Supervisor: Prof Travis Glare (Lincoln University)
Associate supervisor: Prof John Hampton (Lincoln University)
External co-supervisor: Dr Trevor Jackson (AgResearch)
Advisor: Dr Peter Holder (AgResearch)

**Maria Elena Dutra**
Title: Issues affecting vertically transmitted endophytes in perennial ryegrass.
Maria Elena has a BSc in Forestry from the University of the Republic of Uruguay. Her PhD will focus on environmental and agricultural management factors that influence the transmission of two different endophytes in ryegrass. She will also assess ways to improve endophyte viability in storage. Her PhD is funded by GrasslandNZ Technology Ltd.
Supervisor: Prof John Hampton (Lincoln University)
Associate supervisor: Dr Rainer Hoffmann (Lincoln University)
External co-supervisor: Dr Peter Holder (AgResearch)
Advisor: Dr Stuart Card (AgResearch)

**Khan Mir Khan**
Title: Manipulation of radish plant growth to increase seed yield and quality.
Khan Mir gained a BSc (Hons) and an MSc (Hons) from Gomal University, Pakistan, majoring in Horticultural Science. For his PhD, he will investigate the use of plant growth regulators and topping to improve radish seed yield and quality by either preventing lodging and/or increasing reproductive sink strength. This research is being conducted with assistance from South Pacific Seeds (NZ) Ltd and funding from the Government of Pakistan.
Supervisor: Prof John Hampton (Lincoln University)
Associate supervisor: Dr Rainer Hoffmann (Lincoln University)
External co-supervisor: Dr Jason Trewavas (AgResearch Ltd)
Advisor: John McKay (South Pacific Seeds NZ Ltd)

**Cian Hinkson**
Title: Analysis of the transmission of two different endophytes vertically transmitted in tall fescue for establishment failure.
Cian hopes to enhance and improve the seed coating based on entomopathogenic fungi for forestry bioprotection in New Zealand. His PhD research will use artificial neural networks and other quantitative approaches to predict the likelihood of invertebrate pest species establishing in New Zealand. His research aims to improve the reliability of predictions and help manage the implicit uncertainty of ecological data.
Supervisor: Assoc Prof Susan Worner (Lincoln University)

**Ursula Torres**
Title: Modelling global distributions and risk of establishment of invasive freshwater fishes.
Ursula has a BSc and two MSc (Hons) in Ecology and Modelling at Paul Sabatier University, Toulouse, France. Her PhD research aims to predict suitable habitats for invasive invertebrates, using recent advances in theory and methodology. She will use ensemble modeling and attempt to combine mechanistic and correlative distribution models.
Supervisor: Assoc Prof Susan Worner (Lincoln University)

Postdoctoral fellow profiles

**Dr Maud Bernard-Verdier**
Dr Bernard-Verdier has a BSc in Physiology and Cell Biology and an MSc in Ecology and Evolution from the Ecole Normale Superieure of Caen and Paris University XI in France. For her PhD at the University of Montpellier I, France she investigated rangeland plant community assembly along a soil resource gradient using functional and phylogenetic approaches. Her postdoctoral project will investigate the impact of non-native plants on plant community structure. Using an existing vegetation survey of Banks Peninsula, she will be examining how the local abundance of individual species, native or non-native, may be related to changes in species richness.
Advisor: Prof Philip Hulme (Lincoln University)

**Dr Nicholas Cummings**
Dr Cummings has a BSc, BEdSci and PhD in microbiology from the University of Canterbury, New Zealand. He has expertise in the collection, isolation, taxonomy, and phylogenetics of microfungi, including entomopathogenic, endophytic and marine species. He also has experience in the taxonomy of basidiomycete fungi, especially edible species. In his current research, Dr Cummings is working with root endophytic fungi for forestry bioprotection in New Zealand and Southeast Asia, with a focus on developing efficient methods for large-scale Trichoderma spore production.
Advisor: Dr Robert Hill (Lincoln University)

**Dr Peter Holder**
Dr Holder has a BSc from Auckland University and a MPhilSci and PhD from Lincoln University. He worked for 19 years at the Ministry of Agriculture and Forestry (now the Ministry for Primary Industries) as a scientist specialising in invertebrate identification, incidence detection and eradication. Dr Holder's postdoctoral project aims to identify the source of insects that invade New Zealand and distinguish incursions from those that have not. He uses a variety of mass spectrometry techniques to measure stable and radioactive isotope ratios, and trace element concentrations, as point-of-origin markers for insects.
Advisor: Dr Karen Armstrong (Lincoln University)

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