ALLAN WILSON CENTRE
FOR MOLECULAR ECOLOGY AND EVOLUTION

pheno

JUNE 2012 | ISSUE 5

ECOLOGICAL RESTORATION
A COMMUNITY JOURNEY

"Think Globally, Act Locally" is a frequent mantra of environmentalists. Allan Wilson Centre (AWC) researchers are taking that advice in a collaborative project with Te Aitanga-a-Hauiti and the Uawa Tolaga Bay community

Professor Charles Daugherty
Director, Allan Wilson Centre

AWC researchers are internationally known for their discoveries about the evolutionary process and the history of the plants and animals of New Zealand and the Pacific. But in early 2011, Nori Parata, Principal of the Tolaga Bay Area School, and other members of the community approached the AWC for advice and assistance on a different aspect of biodiversity: a project to re-vegetate the banks of the Uawa River near the local school and restore other habitats along the river mouth. In February 2011, a group of AWC members and I visited the community to discuss how such a project might work. We left enthusiastic to begin work.

But what work? The term ecological restoration means returning the environment to some previous condition. In New Zealand, this often means restoring habitats to conditions resembling those prior to human arrival about 800 years ago, with no evidence of human impacts such as introduced mammalian pest species. In the case of Zealandia, a project in Wellington City, an entire valley has been surrounded by a mammal-proof fence and all mammal species removed. Zealandia has a 500 year vision that includes regrowth to maturity of the wonderful lowland forest that carpeted the Wellington landscape a thousand and more years ago. The people of Wellington are already benefitting from the return of birds to the city and the slow return of the native forests in the valley, but humans enter only as visitors, not as inhabitants of an environmentally healthy valley.

The people in Tolaga Bay expressed a quite different vision for restoration. They take pride in the descriptions of their community from the observers on the 1769 visit of Cook's Endeavour. Cook and his companions reported finding numerous "Cultivations". The rich soils of the Uawa catchment provided a food basket that supported a thriving community of more than 1000 Te Aitanga-a-Hauiti people. They described the area as "agreeable beyond description."

The Hauiti people still make Tolaga Bay their home, along with other more recently arrived peoples. Our discussions with the people of the Uawa Tolaga Bay community have taught us that their vision for ecological restoration identifies the time of Cook's arrival as their restoration target. In other words, the goal is to re-create a prosperous community in a healthy environment. A human presence is an integral part of this restoration vision.

INSIDE THIS ISSUE

Over the past year, AWC members have worked with professional environmental consultants to explore ways to begin the process of ecological restoration along the Uawa River, as originally proposed, but also to think of restoration as it relates to the economic and cultural dimensions of the people. Our discussions began with the Tolaga Bay Area School community, and have expanded to many other groups: local farmers, business people, foresters, health providers, and a wide range of interested individuals.

Environmental and community developments only work if they capture the aspirations of the local people. As an independent national organisation, the Allan Wilson Centre has committed to supporting the people of the Uawa Tolaga Bay community to discover and pursue a vision for their future. On June 6, at celebrations of the Transit of Venus, the event that ultimately brought Cook and the Endeavour to Tolaga Bay, the results of our year's work will be presented to the local community.

The theme of the Transit of Venus events this year is "Dual Heritage – Shared Future." We have learned of the importance of the river to the community, not only ecologically, but as a tangible geographic feature linking all peoples of this special place. Beginning restoration with the river symbolises a commitment to discovering a vision for a better future – a Shared Future - for the community. Allan Wilson Centre members are proud to work with the people of Uawa to seek a pathway to that Shared Future.

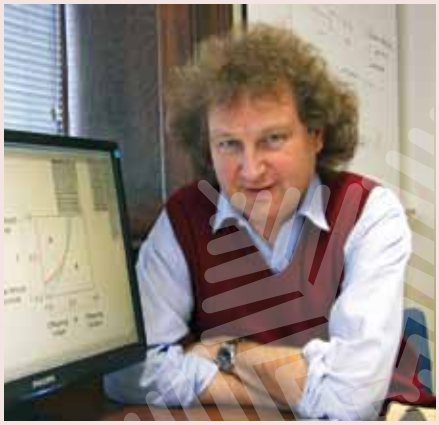
HAMISH SPENCER'S APPOINTMENT AS DIRECTOR

From August 2012 the Allan Wilson Centre will have a new director as Professor Hamish Spencer takes over from Professor Charles Daugherty, who is stepping down after three years at the helm. Hamish is an evolutionary geneticist at the University of Otago's Department of Zoology and was Head of Department there from 2009 to 2011. He is also a Fellow of the Royal Society of New Zealand, holds an appointment as an Honorary Research Fellow at the Liggins Institute, University of Auckland, and is a Principal Investigator in another Centre of Research Excellence (CoRE), the National Research Centre for Growth & Development.

Hamish has a wide variety of research interests, from human genetics to the evolution of snails, birds, parasites and algae. Much of his work uses mathematical modelling to understand how populations evolve and respond to natural selection. He is best known internationally for his work on genomic imprinting, an unusual feature of mammalian development where expression of a gene in an individual differs depending on whether it is inherited from the mother or the father. Hamish also has an interest in the history of the eugenics movement, and a paper he co-authored in Plos Biology in December 2008, on the laws and attitudes to first-cousin marriage, received worldwide media attention.

Hamish says he is both excited and honoured to have been appointed Director of the Allan Wilson Centre. "In my view, the AWC is doing some of the most exciting research in evolutionary biology worldwide - research that really matters to New Zealand, economically, socially and educationally," he says. "My goal is to lead the AWC in such a way as to showcase this research to the country and to the world." He also aims to work with the other investigators to grow the Centre towards a successful re-bid for funding in 2014/15. "At this stage everyone can be planning ahead, thinking of ways to make the AWC an even better organisation," he says. "Thanks to the hard work of the outgoing Director Charles Daugherty, the Centre is in a very healthy position, one from which its future looks very bright indeed."

Hamish is currently on sabbatical leave at the University of Bath, England, where he was awarded a David Parkin Visiting Fellowship. He will be returning to New Zealand in June and taking up his new appointment in early August.



Professor Hamish Spencer
Picture courtesy of the University of Otago

MODELLING THE LOSS OF GENETIC DIVERSITY IN OUR NATIVE BIRDS

What really happens when a species goes through a population crash? Even though their numbers may recover, the subsequent loss of genetic diversity can make a species more vulnerable to disease. Otago University PhD student Jolene Sutton is investigating whether two of our iconic native bird species, saddlebacks and robins, have lost vital genetic diversity at immune genes through population declines caused by the introduction of mammalian predators.

Many predictions about what happens, from a genetic perspective, when a population's numbers decrease are based on neutral genetic markers like microsatellites – markers that don't code for functional genes. However, these markers might not give an accurate picture of variation at genes that are important for survival and reproduction. For instance, immune genes may be under selection because of their role in pathogen resistance, so might retain more variation than neutral markers through a population crash.

Jolene tested whether this is the case by analysing the results of previous studies across 22 species that reported levels of both neutral and immune genetic variation following population declines. She found that, contrary to expectations, more variation was lost at immune genes than at neutral markers, showing that when populations become small they may end up even more susceptible to disease than previously thought. Her findings were published in the top international journal Molecular Ecology in November last year, and won her Otago University's Elizabeth Mason Prize for the best paper published by a female Zoology student in a peer-reviewed journal.

Jolene is now investigating whether this holds true for New Zealand robins and saddlebacks. Both of these species have a history of population decline: saddlebacks were extinct on the New Zealand mainland by the early 1900s and now only survive on offshore islands. Although their population numbers are now increasing thanks to establishment of many new populations in predator-free reserves, all birds are descended from only a few small populations so have extremely low genetic diversity. New Zealand robins are more numerous than saddlebacks and are still found throughout mainland New Zealand, but they too have experienced declines as their populations have become fragmented by habitat clearance and the introduction of mammalian predators.

While most studies of threatened species only measure variation in present-day populations, Jolene is going a step further by also measuring variation in museum specimens. This will enable her to assess how much variation robin and saddleback populations had before their populations started declining, providing a far more accurate picture of what happens during a bottleneck than previous studies have shown. So far Jolene has focused on neutral genetic markers, finding that saddlebacks have lost more of their historic neutral genetic diversity than robins, and that South Island populations were more severely affected than those on the North Island. These results match expectations based on population declines - saddlebacks experienced more severe declines than robins, and declines were greatest in the South Island. Immune genes show a similar pattern of loss of genetic diversity, and Jolene is currently testing whether this loss is comparable to the loss of microsatellite diversity.

Jolene is supervised by new AWC Principal Investigator Associate Professor Ian Jamieson. She came to New Zealand from Canada in 2009 to begin her PhD and aims to finish later this year. Her project is part of a government-funded initiative aimed at reducing extinction risk in native species by sustaining genetic diversity. She hopes that her results will contribute vital information on how best to maximise immune diversity in threatened populations and thus minimise potential disease threats.

New Zealand Robin (Toutouwai) with weta
Picture courtesy of Alexei Drummond

NEW ZEALAND: EVOLUTION'S UNIQUE EXPERIMENT

When the first New Zealanders set foot on Aotearoa, they would have encountered an array of weird and wonderful creatures. Large flightless birds, taller than any man, giant eagles, nocturnal parrots, and bats that forage on the ground inhabited our lush rainforests. In this article, we take a look at how geology and human arrival have shaped which plants and animals now call New Zealand home.

Two cicadas
Picture courtesy of Ashley Wolcotts

New Zealand's biota is very different from elsewhere – the result of millions of years of isolation, both from other landmasses and from humans. Australian environmentalist and author Tim Flannery has called New Zealand "a completely different experiment in evolution from the rest of the world." The absence of evolutionary pressures like predatory mammals allowed the evolution of some unusual features in our flora and fauna, such as gigantism, flightlessness and nocturnality. But even some of our most unusual, iconic species may not be as old as we originally thought.

The New Zealand landmass split off from the southern continent of Gondwana around 80 million years ago, and has been isolated ever since. However, surprisingly few of the ancestors of our iconic species were on the "ark" when it split off from Gondwana. Molecular analyses are showing us that many species originally assumed to be of Gondwanan origin are in fact more recent arrivals. In fact, around 20 million years ago New Zealand's landmass was reduced to a fraction of what it is now thanks to rising sea levels, a phenomenon known as the Oligocene drowning. Some scientists believe that New Zealand was entirely underwater during this time, and thus the entire terrestrial flora and fauna of early New Zealand was lost. If this is the case, all of the species inhabiting the New Zealand landmass today must have arrived from across the sea in the last 20 million years.

This is a controversial hypothesis, supported mainly by geological data showing the existence of limestone, which is of marine origin, throughout the country. The fossil record in New Zealand prior to 25 million years ago is extremely poor so provides little information on which of our present-day flora and fauna were in New Zealand before the Oligocene.

Data from DNA may be the best bet for settling this debate. Already genetic data has shown that many native species, including skinks, freshwater fish, and many of our native birds and plants, arrived within the last 20 million years by dispersing across the ocean from Australia. Molecular data also show that groups such as moa, wrens, cicadas and some plant lineages went through a genetic bottleneck at some point in their past, followed by a burst of evolutionary speciation within the last 20 million years. This is consistent with these species first being reduced to small numbers and then expanding into new environments as sea levels dropped again and new land emerged.

But for some species a New Zealand origin less than 20 million years ago doesn't seem to fit.

For example, the closest known relatives of tuatara died out 65-80 million years ago, and they are unlikely to disperse across the sea. If they did arrive from Australia within the last 20 million years we would expect to find evidence of close relatives of tuatara either still living in Australia or present in fossilised remains. In addition, genetic data from kauri, kiwi, wrens and native bats indicate that these species diverged from their closest relatives millions of years before the Oligocene drowning. This strongly indicates that they were isolated in New Zealand well before this time, either through continued presence on Gondwana since it broke off, or through early dispersal to New Zealand, perhaps during the Eocene 30-60 million years ago.

Whether New Zealand was completely underwater or only partly submerged 20 million years ago is still up for debate. But either way, the Oligocene drowning had a profound effect on the makeup of our flora and fauna, with the loss of many original Gondwanan species and the arrival and radiation of many new species.

An audit of prehistoric New Zealand

In more recent times, human arrival has strongly influenced our native flora and fauna. Allan Wilson Centre Principal Investigator Professor Jon Waters is testing the idea that human settlement of New Zealand led to the extinction of a previously unrecognised treasure trove of unique coastal animal species. For instance, New Zealand's rarest penguin, the yellow-eyed penguin, was thought to be widespread throughout New Zealand in prehistoric times but is now confined to Otago and Southland.

Professor Jon Waters
Allan Wilson Centre Principal Investigator

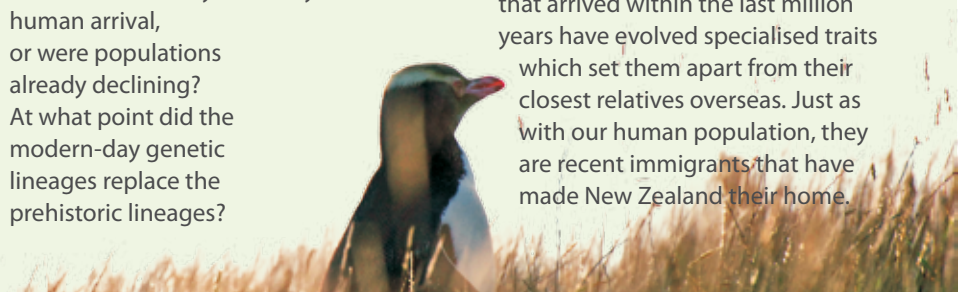
However, research by Jon's group has shown that yellow-eyed penguins are not a declining remnant of a once abundant species, but are actually recent colonisers from the subantarctic. Fossil bones from an earlier species found throughout New Zealand, originally thought to be from the yellow-eyed penguin, are now known to be from a different species that went extinct shortly after humans arrived in New Zealand. The extinction of this prehistoric species, named the Waitaha penguin, allowed the yellow-eyed penguin to expand their subantarctic population into Otago and Southland.

Jon believes that many other iconic coastal species, including the New Zealand sea-lion, little blue penguin and crested penguin, may actually be new arrivals from overseas that have capitalised on the human-mediated extinction of prehistoric species to gain a foothold here. He is testing this idea by sequencing ancient DNA from fossilised bones and comparing it to DNA samples from present-day populations. He aims to determine whether the fossil remains of species such as sea lions and penguins represent different genetic lineages from the present-day populations.
If so, this would suggest that the present-day populations are not descendants of these prehistoric populations, but instead moved into New Zealand after the prehistoric populations died out.

By sequencing DNA from a large number of fossilised bones, which will be carbon-dated to determine their age, and applying some advanced phylogenetic methods, Jon and his team aim to determine exactly when these prehistoric populations began to decline. Did they suddenly die out after human arrival,
or were populations already declining?
At what point did the modern-day genetic lineages replace the prehistoric lineages?

These questions will enable the researchers to investigate how the human settlement of New Zealand affected our coastal fauna, and to determine what New Zealand was really like before human arrival.

More and more, genetic data are showing us that not all of our well-known native species have a long history in New Zealand. But evolution can happen quickly, and even species that arrived within the last million years have evolved specialised traits which set them apart from their closest relatives overseas. Just as with our human population, they are recent immigrants that have made New Zealand their home.



NOVEMBER TOUR BY GENETICIST AND WRITER, STEVE JONES

Professor Steve Jones, a well-known geneticist and prize-winning popular science writer, will visit New Zealand in November for a series of public lectures sponsored by the Allan Wilson Centre.

Professor Jones is an Emeritus Professor at University College in London, and writes widely on science issues in the British media, including a regular column in the Daily Telegraph newspaper where he tackles subjects as diverse as human genetics, health, physics and climate change. He has published several popular books on biology and evolution, including *In The Blood: God, Genes and Destiny, Almost Like a Whale*, and *The Language of Genes*, which won the Rhône-Poulenc Science Books prize, one of the world's most prestigious science writing awards.

Professor Jones' skills as a science communicator won him the Royal Society Michael Faraday Prize in 1996, which is given annually to the scientist who has done the most to further the public understanding of science. He is known as an engaging, witty writer and educator who is skilled at "making the science go down easily." His most recent book, *The Darwin Archipelago: The Naturalist's Career Beyond Origin of Species*, traces the contributions that Charles Darwin's lesser known books made to modern biology, and has won rave reviews from critics.

As a scientist, Professor Jones is best known for his work on genetic diversity. His research uses snails, fruit flies and humans to answer questions about why genetic variation exists, and how it is shaped by the environment. He is also a proponent of the controversial idea that human evolution has slowed or stopped in modern times. Details of Professor Jones' visit will be publicised soon.

OTAGO'S IAN JAMIESON AND NEIL GEMMELL ADD TALENTS TO THE ALLAN WILSON CENTRE

Two new Principal Investigators joined the Allan Wilson Centre team in January 2012 – Associate Professor Ian Jamieson and Professor Neil Gemmell, both from Otago University. In this article we look at their research.

Professor Neil Gemmell

An ambitious plan to understand our oldest surviving New Zealander

The appointment of Professor Neil Gemmell to the Allan Wilson Centre will mean an increased focus on genomics for the Centre. Neil is the AgResearch Chair in Reproduction and Genomics and the inaugural Director of the Centre for Reproduction and Genomics at the University of Otago. His research applies recent technological spin-offs from the various genome projects to problems in ecology, evolution and conservation biology. Reproduction is a central theme in his research, with past and current projects in his lab investigating aspects of mating systems and mate choice, sperm-egg interactions, sperm function, sex determination, and inter-sexual genomic conflict. He is also interested in how genomes evolve, and is well-known for his work on the evolution of small repetitive DNA sequences called microsatellites. Microsatellites are widely used as markers in population genetics and are generally assumed to be non-functional, but Neil's recent analysis of microsatellites in the platypus genome showed that many are actually highly conserved across mammals, indicating they have an important functional role to play.

The Allan Wilson Centre will support Neil's ambitious new plan: to sequence the tuatara genome. Tuatara are close to many New Zealanders' hearts as one of our most treasured and iconic species, but they are also of extraordinary interest to evolutionary biologists and zoologists across the world. They are the most distinctive living reptile in the world, being the only surviving member of an entire lineage of reptiles that last shared a common ancestor with other reptiles some 220-250 million years ago. The genome project has the potential to help researchers understand several unusual aspects of tuatara biology, including extreme longevity, cold adaptation and a rare pattern of temperature-dependent sex determination, and promises to be of enormous interest to researchers in evolution and development worldwide. "This project will be nationally and internationally significant for its bearing on our understanding of vertebrate evolution and the enhancement of tuatara conservation", says Neil.

Advances in DNA sequencing and computational technology mean much of the genome project will be able to be done in New Zealand, instead of having to rely on large genome centres overseas. The project will be a highly collaborative affair, with input from no less than half of the AWC's Principal Investigators, as well as New Zealand Genomics Ltd, Auckland-based software company Biomatters, and the Beijing Genomics Institute. The Department of Conservation and iwi group Ngatiwai will also play a central role in the project. Ngatiwai will be strongly involved as a collaborator in all decision making regarding the use and distribution of the data from the project, something which Neil says will set a new precedent for iwi-science partnerships.

Neil says becoming part of the Allan Wilson Centre was a logical progression as he already works closely with a number of the other Investigators in the Centre. For instance Neil, Lisa Matisoo-Smith, Ian Jamieson, David Bryant and members of their respective teams are working on an on-going project applying next-generation sequencing data to conservation issues. He also hopes to establish new collaborations across the Centre. "I am looking forward to drawing on the skills and knowledge of others in the AWC to help us solve some of the problems that our group has been tackling," he says.

Tuatara on Stephens Island
Picture courtesy of Sue Keall

Professor Ian Jamieson
Picture courtesy of Otago University

Helping New Zealand's native birds survive: inbreeding and disease resistance

The questions conservation managers often ask when establishing new populations of our most threatened species are - should individuals from multiple populations be combined to establish new populations, and should small isolated populations be supplemented by new genetic stock from time to time? Associate Professor Ian Jamieson's research aims to answer these questions, improving the long-term prospects for some of our most threatened species.

Like Allan Wilson, Ian has always had a strong interest in avian biology. He leads Otago University's Threatened Bird Research Group, which focusses on understanding the roles of inbreeding and loss of genetic diversity in the decline of New Zealand's threatened birds. His research group, which comprises six postgraduate students and one postdoctoral fellow, works on some of New Zealand's highest profile endangered bird species, including saddlebacks (tieke), robins (toutouwai), kakapo and takahe. Like many other native birds, these species have suffered population losses through the introduction of mammalian predators and habitat reductions, and now persist only in isolated populations. Using a mix of field work, molecular genetics and population modelling, his group aims to determine how inbreeding and loss of genetic diversity in these species affect their productivity and survival, and how reintroduction programmes can best be managed to maximise genetic diversity and ensure their long-term survival.

With his appointment to the Allan Wilson Centre, Ian has embarked on a new Strategic Research Initiative which aims to investigate how loss of genetic diversity affects disease resistance in takahe, saddleback and kakapo. He will investigate whether these species have lost variation at immune-related genes that may hamper their ability to respond to disease. "In New Zealand, unless a population is in imminent danger of being wiped out by a disease, the longer-term consequences of loss of diversity in immunity-related genes tends to be under-appreciated by conservation managers," he says. This new project will tease out the relationship between disease susceptibility and variation at immune genes, providing conservation managers with important new information to improve the success of threatened species programmes.

Ian says he is looking forward to working with the other Allan Wilson Centre Investigators and tapping into their expertise. "The biggest advantage for me in joining the AWC is the increased opportunity to collaborate with some of the top evolutionary biologists in the country," he says. His appointment will strengthen the Centre's links with the Department of Conservation: Ian is a long serving science adviser to a number of Department of Conservation recovery programmes and is part of a government-funded programme, led by Landcare Research, responsible for providing guidelines on sustaining genetic diversity for national recovery programmes.

Using a mix of field work, molecular genetics and population modelling, his group aims to determine how inbreeding and loss of genetic diversity in these species affect their productivity and survival.

Otago University's Threatened Bird Research Group
Picture courtesy of Ian Jamieson

FROM AFRICA TO AOTEAROA: A NEW POWERPOINT TO TEACH HUMAN EVOLUTION

How did humans evolve from ape-like ancestors in Africa into a modern species occupying every part of the globe? PowerPoint presentations produced by the Allan Wilson Centre aim to help high school biology teachers guide their students through the human evolution journey.

The first presentation, entitled "The Story of Human Evolution", introduces evolutionary concepts using the story of human evolution as an example, and highlights the contributions that Allan Wilson made to our understanding of human evolution. The presentation comes in two parts: in Part one, students learn how scientists study our evolutionary history, using evidence such as fossil remains and genetics to form theories about evolution, and how these theories may change as new evidence is found. Part two covers adaptation and evolution in modern humans, discussing how natural selection acts on genetic variation with examples such as eye colour and disease resistance, and posing the question 'Are we still evolving?'. This presentation is geared towards Year 10 students, but will also be useful for senior biology students or anyone wanting an interesting introduction to human evolution and the work of Allan Wilson.

..."From Africa to Aotearoa" concentrates on the evolution of modern humans and their migration out of Africa in the last 100,000 years...

The second presentation, "From Africa to Aotearoa," concentrates on the evolution of modern humans and their migration out of Africa in the last 100,000 years, and is aimed at Year 12 and 13 biology students. The presentation shows how new genomics research is refining our ideas about human evolution and enabling researchers to trace the footprints of our ancestors as they spread from Africa through Europe, Asia, the Pacific and finally to New Zealand. It covers recent findings that Homo sapiens interbred with Neanderthals and other ancient human lineages as they spread across Europe and Asia, and addresses what "race" really means from a genetic perspective. The presentations were created by Allan Wilson Centre researcher, Dr Hilary Miller, in collaboration with biology teacher, Dr Azra Moeed, from Victoria University's Faculty of Education. They fit with the Nature of Science and Living World curriculum objectives by showing how scientists gather evidence and come up with theories based on this evidence.

The presentations can be downloaded from the Allan Wilson Centre website (www.allanwilsoncentre.ac.nz) under the 'Teachers and Students' tab. Each presentation is accompanied by notes for teachers and can be edited if teachers wish to customise it for their class.

Australopithecus - an ape who walked on two legs, from "The Story of Human Evolution" part one

CONTACT US

Ms Wendy Newport-Smith
Centre Manager

Phone: +64 6 350 5448
Fax: +64 6 350 5626
w.newport-smith@massey.ac.nz

HOST INSTITUTION

Postal Address:
Allan Wilson Centre for Molecular Ecology and Evolution (AWC)
Massey University,
Private Bag 11 222,
Palmerston North

Courier Address:
Allan Wilson Centre,
Level 2,
Science Tower B,
Massey University, Private Bag 11 222
Palmerston North

PARTNER INSTITUTIONS

Massey University,
Private Bag 11 222, Palmerston North

The University of Otago,
P.O. Box 56, Dunedin

The University of Auckland,
Private Bag 92019, Auckland

Victoria University of Wellington,
P.O. Box 600, Wellington

Canterbury University,
Private Bag 4800, Christchurch

Plant and Food Research,
120 Mt Albert Road, Sandringham,
Auckland 1025

Visit the Allan Wilson Centre at
http://www.allanwilsoncentre.ac.nz/