

ANNUAL REPORT

2012 PART I



Landcare Research
Manaaki Whenua

Outcome 1 :

- A consistent biodiversity assessment system for all of New Zealand (page 10)
- Effective wetland restoration: adding value to land & water assets (page 12)
- Invasive species management at landscape scale for conservation benefit (page 13)
- Choosing the 'best targets' for biocontrol of environmental weeds (page 13)

Outcome 2 :

- S-map to fine tune land management results in significant economic benefit (page 16)
- Smarter management of water quality issues at the regional scale (page 18)
- Understanding national ecosystem services trends (page 18)

INNOVATION HIGHLIGHTS

Outcome 3 :

- Predicting future forest growth under climate change in New Zealand (page 22)
- The carbon storage impacts of pasture reverting to indigenous scrub (page 22)
- Improved estimates of nitrous oxide emissions & emission factors significantly benefit New Zealand (page 23)

Outcome 4 :

- Diagnostic tools supporting national biosecurity (page 29)
- An objective framework for declaring areas free of TB (page 30)



LANDCARE RESEARCH AT A GLANCE

Our Vision

Science and environment for a better New Zealand

Our Core Purpose

To drive innovation in New Zealand's management of terrestrial biodiversity and land resources in order to both protect and enhance the terrestrial environment and grow New Zealand's prosperity.

Our National Outcomes

- Improved measurement, management and protection of New Zealand's terrestrial ecosystems and biodiversity, including in the conservation estate
- Sustainable use of land resources and their ecosystem services across catchments and sectors
- Improved measurement and mitigation of greenhouse gases from the terrestrial biosphere
- New Zealand industries and organisations have increased ability to develop within environmental limits and meet market and community requirements

Our Scope of Operation

Landcare Research is recognised as the lead Crown research institute (CRI) in the following areas:

- Catchment-level ecosystems (including wetlands) and related ecosystem services
- Terrestrial vertebrate pest control
- Terrestrial carbon processes and inventory, and other greenhouse gases from soil and land
- Land cover, land use capability and effects, and spatial and information that integrates across sectors and scales
- Soil characterisation, processes and services
- Integrated social and biophysical research to support the sustainable management of terrestrial biodiversity and land resources

Landcare Research is expected to work with other research providers and end-users to contribute to the following:

- Biosecurity, land, soil and freshwater management
- Climate change adaptation and mitigation
- Industry and business environmental performance including verification
- Indigenous forestry
- Urban environments
- Antarctica

Our Organisation

Landcare Research is one of eight Crown research institutes (CRIs) formed in 1992. CRIs function as independent companies but are owned by, and accountable to, the New Zealand Government. Our shareholders are the Minister of Finance and the Minister of Business, Innovation and Employment. We have 380 staff at nine locations across New Zealand, including our subsidiary carboNZero Holdings at Lincoln and Auckland. Our science revenue (about \$59 million per year) is derived primarily from contracts with the Science and Innovation Group with the Ministry of Business, Innovation and Employment (formerly MSI), Ministry for the Environment (MfE), Ministry for Primary Industries (MPI), Department of Conservation (DOC), Animal Health Board (AHB), regional, city and district councils, private sector businesses and organisations, and Māori organisations.

Manaaki whenua – Manaaki tangata (Care for the land – Care for the people)

Our Māori name means to care for the land in all senses. Māori are tangata whenua, the indigenous people with whom we consult and collaborate. Our recognition of and respect for Māori as tangata whenua is reflected in our Vision Mātauranga strategy.

www.landcareresearch.co.nz



| | | | |
|------------------------------------|----|--|-------------------|
| Innovation Highlights | 01 | Landcare Research at a Glance | 02 |
| Chair & Chief Executive's Review | 04 | Science Framework | 07 |
| Biodiversity (Outcome 1) | 08 | Land Resources (Outcome 2) | 14 |
| Greenhouse Gases (Outcome 3) | 20 | Industries & Organisations (Outcome 4) | 26 |
| Engaging our Stakeholders | 31 | Vision Mātauranga | 34 |
| Science Excellence & Collaboration | 36 | Informatics & Systematics | 43 |
| Knowledge & Technology Transfer | 46 | Our Organisation | 50 |
| Awards | 57 | Financial Performance Summary | 58 |
| Directory | 60 | Glossary & Photo Credits | Inside back cover |



CHAIR & CHIEF EXECUTIVE'S REVIEW

Landcare Research exists because New Zealanders care about their natural environment. Whether in business, on the farm, in urban communities or in their recreation, New Zealanders want their natural environment to be healthy because it is central to the identity, liveability and future prosperity of the nation. Landcare Research provides an understanding of the health of the natural environment and tools that will help protect that health and grow our national prosperity. Our scientists work with our stakeholders in business, government and the community to make the fruits of our work readily accessible and useful. Therefore our vision is 'science and environment for a better New Zealand'.

In line with the other Crown research institutes (CRIs) we have implemented recommendations of the 2010 CRI Taskforce and worked on implementing the 5-year strategies in our 2011–16 Statement of Corporate Intent. Our science is now more dynamically aligned to our stakeholders' priorities. We have introduced new lines of research reflecting contemporary issues in policymaking and the support of trade. Our International Science Advisory Panel has started its 3-year term; and we have refreshed both our senior and science leadership teams.

Our net surplus in our Parent science business exceeded budget (\$1.9m vs \$1.6m). Revenue in our science business was \$58.3m (compared to a target of \$57.5m),

which is pleasing given budget constraints for many of our government clients.

During the year we sold our subsidiary Sirtrack Limited to Lotek Wireless Inc, the global market leader in wildlife telemetry. Sirtrack revenue at the time of sale was \$1.8m compared with a full year budget of \$4.8m. Sirtrack has been disclosed in our annual report financials as a discontinued operation. carboNZero Holdings Limited, which includes the carbon footprint management programme, was corporatised and invested for international growth. However, growth fell short of expectations and a new strategy is in place to attract external investment and expertise. The impacts of that shortfall have contributed to a Group revenue of \$59.3m (excluding Sirtrack) versus a comparable target of \$61.4m. Group return on equity (including subsidiaries and investments in new science and infrastructure) was 4.9% (compared to a target of 5.3%).

Landcare Research's focus is upon contributing to desired National Outcomes in environmental asset management through working with our stakeholders. This report contains many examples of those contributions.

By increasing the ability of government organisations to use consistent methods for assessing the state of biodiversity and the threat of species extinction our

L-R: Hon John Luxton, Tania Simpson (Deputy Chair), Gavan Herlihy, Jo Brosnahan (outgoing Chair), Peter Schuyt (back, Chair), Richard Gordon (front, Chief Executive), Vicki Taylor, Emily Parker *Delwene Pupuo*

science is making an important contribution towards sustaining our national biodiversity assets (Outcome 1, page 8). Tools we have developed will enable agencies to pre-assess pest species for the suitability of control by biological agents; and we have produced wetland restoration manuals that assist companies, councils and communities engaged in restoring these much-depleted habitats.

Our development of the National Land Resource (NLRC) web portal, which enables collaboration across science, government and the private sector, is making information, data and services for sustainable land use more readily available. Our S-map Online is increasingly valuable to land managers making land use and soil husbandry decisions, and several lines of our research are supporting the development of precision irrigation and the sustainable intensification of agriculture (Outcome 2, page 14).

We are making good progress towards Outcome 3 (page 20). Improved understanding of the dynamics of greenhouse gases in natural and farmed systems is helping to reduce uncertainties in national inventories, and has demonstrated the potential for reducing nitrous oxide emissions from agriculture. This year we launched a new 5-year project in partnership with dairy company Synlait and other science organisations, investigating changes in emissions and soil carbon with land conversion to dairy farming.

In our operating environment we have seen an increase in support for – and expectations of – science in both innovation and economic development. The private sector has begun to take a stronger role in seeking solutions to climate change and for the stewardship of our natural assets. This reflects their need to secure a ‘sustainable licence to operate’ from local communities and international markets. Our science and knowledge have contributed across a range of areas of compliance and competitive advantage (Outcome 4, page 26).

We have been pleased to welcome more major companies to our carboNZero^{Cert}™ (greenhouse gas) and

Enviro-Mark[®] (environmental management) certification programmes. Toyota NZ is now a member of both, with its national dealership joining Enviro-Mark and working towards Gold certification. Membership of the carboNZero programme by Ricoh in New Zealand has contributed to their Australian operations also joining; and in the UK, members of carboNZero’s CEMARS[®] certification scheme include the Environment Agency, the Scottish Parliament, Volvo and a number of major utilities.

Landcare Research seeks to be at the leading edge of change in the role that science plays for government policy, industrial sector strategy and community conversations on the terrestrial environment. Therefore this year we initiated a series of regular science and policy seminars in Wellington that have attracted a significant audience; and we contributed to the sustainability debate in the private sector through active membership of Business New Zealand and the newly-formed Sustainable Business Council. The Land and Water Forum has been a leading example of bringing diverse stakeholders together to address complex challenges (and opportunities) in a collaborative manner; and we have been pleased to contribute technical support to the Forum.

Our Vision Mātauranga strategy (page 34) embodies the importance of our relationship with tangata whenua and Māori organisations and the desire for our science to work alongside their world view. This report contains examples of our continuing and productive relationships, for example with the Tūhoe iwi on finding appropriate models for conservation governance and sustainable use of natural assets.

Our role includes maintaining national science capability in our specialist fields. We are pleased that international benchmarking has recognised the impact of our published papers is 50% higher than the world average, and our ‘excellence rate’ (papers included among the most cited papers in relevant scientific fields) is the highest for any New Zealand university or CRI. We work with some of the world’s best science teams and organisations; and we play important roles in many international projects.



Our scientists continue to be recognised nationally and internationally with awards for their expertise and achievements (see page 57).

We have also invested strongly in our science facilities (page 54), upgrading our greenhouse gas research and national plant collection facilities at Lincoln and contributing to the National e-Science Infrastructure Project (page 44), which will enhance the computing resources and connectivity available to New Zealand's scientists.

The CRIs' shareholding Ministers are interested in how the performance of a CRI changes over time, and in how a CRI can improve its performance. The CRI Taskforce recommended that each CRI be monitored against key performance indicators. Engagement with stakeholders is vital to developing and delivering maximum value from our scientific research. We put much effort into engaging with our stakeholders; so it is pleasing that the recent MBIE-commissioned survey showed that our key stakeholders are satisfied with their engagement and influence on Landcare Research's science investment and priority-setting (page 7); 97% of them had used knowledge or tools that came from our research (page 49).

Corporate sustainability is a significant goal for Landcare Research and is achieved through the difference we can make for other organisations, enhancing their sustainable economic development; strengthening social capital in



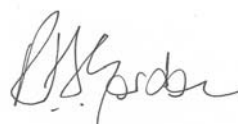
Chair Peter Schuyt

our own community; and lessening the environmental impact of our own activities. It remains a challenge for us to assess indirect impacts; but the results of reducing our direct impacts have been pleasing this year and are reported on our sustainability website.

www.landcareresearch.co.nz/about/sustainability/

We face a challenging year in meeting financial targets as the global financial environment continues to favour extreme caution in public and private sector expenditure. But we have a positive outlook for achievements in 2012/13, through working closely with the business sector, government, Māori organisations and the wider community as they seek pathways for sustainable economic development. We are being proactive in developing opportunities for science, government and business partnership to achieve sustainable, green growth of land-based enterprises, especially in the cluster centred on Lincoln and Canterbury; and this will be one of our contributions to the Christchurch earthquake recovery. In New Zealand especially, investment in the natural environment is an investment in the economy; and it is our role in Landcare Research to help make that connection.

CRIs came into existence on the 1st July 1992. In July this year, we were delighted to celebrate our 20th anniversary and all staff were presented with a small gift of an inscribed native wood chopping board made from timber salvaged from earthquake damaged buildings in Christchurch.



Chief Executive Dr Richard Gordon

Change of Board Chair

At the end of 2011/12, Landcare Research and the Board of Directors bid farewell to outgoing Chair Jo Brosnahan. Jo had been a director for six years, including five years as Chair. We benefited greatly from her leadership skill, governance expertise, and careful attention to building the culture of the organisation.

Peter Schuyt is our new Chair. He joined the Board in 2009 and was Deputy Chair. Peter brings considerable depth of expertise from previous senior executive and

directorship roles in a diverse group of companies. Peter accepted the new role saying, 'it is a privilege to chair an organisation that plays a special role in New Zealand's future and reflects the importance that New Zealanders ascribe to their natural environment and its wise use.'





SCIENCE FRAMEWORK

GOAL Landcare Research's science framework is clear, effective and facilitates engagement with stakeholders who support our approach to achieving our Core Purpose and National Outcomes.

◆ National Outcomes and Impacts

National Outcomes will be achieved by many organisations working together across the public and private sectors. For each Outcome, we have identified two Impacts, which focus on (1) status and trends – what natural assets are there, what value they have or could have, and (2) management and policy solutions – the ways we both use and sustain these assets. Key performance indicators spanning a 5-year time frame help us gauge progress. We report on these in the following pages along with significant research highlights.

During the year, we worked with key stakeholders to develop Outcome investment strategies and to prioritise the research needed over the next few years to deliver our Impacts and Outcomes. The research priorities will be delivered through 10 Portfolios of complementary science. Portfolios are flexible and integrate with each other, making connections and developing relevant science at local and national scales. Portfolios may contribute to different Impacts and Outcomes simultaneously. They are the focal point for engaging with stakeholders and being responsive to their needs and also our operating environment.

Since the Portfolios were formed, we have been working with stakeholder to plan science initiatives for the next five years, identify key partners and what their roles are in the initiatives, and to agree on significant knowledge and technology transfer activities. These have been summarised in our next Statement of Corporate Intent for 2012-17. More details can also be found on our web site.

KPIs

The MSI Group in MBIE commissioned Colmar Brunton to conduct an independent Stakeholder Survey across a wide range of organisations, and 61 stakeholders commented on Landcare Research.

- 83% are satisfied with the way we set research priorities
- 84% say the relationship they have with us is effective
- 91% have confidence that we have the ability to put together the most appropriate research teams
- 87% of those interacting with us in the past 3 years are satisfied with the overall quality of their experience

Also see Stakeholder Engagement (page 33) and Science Collaboration & Excellence (page 42).



OUTCOME 1 BIODIVERSITY

Improved measurement, management, and protection of New Zealand's terrestrial ecosystems and biodiversity, including in the conservation estate

► Rationale

The integrity of our iconic natural places – and the biodiversity they support – is central to our identity, lifestyle and the economy. Intergenerational responsibility for the management of indigenous ecosystems, expressed through kaitiakitanga, is also central to Māori aspirations.

Since human settlement of New Zealand, many ecosystems have declined extensively in area and function, often as the result of invasive species. Although one-third of New Zealand's land area is legally protected, there is a strong bias in these areas toward montane and alpine regions. Many of our naturally uncommon ecosystems occur outside protected areas. Lowland and dryland ecosystems are facing increasing threats from agricultural intensification, conversion to plantation forestry, mining, urban development and invasive species.

On the other hand, large tracts of retired marginal land have naturally regenerating native vegetation. Biodiversity also benefits from the network of wildlife sanctuaries

covering 56 000 ha of New Zealand. (We host the sanctuariesnz.org.nz website and coordinate an annual workshop for sanctuary stakeholders.)

The effective management of biodiversity must be undertaken in the context of more complete knowledge of its composition and of changes in its state through time and in different ecosystems. This will allow the most threatened components of biodiversity to be identified and addressed through targeted research and effective management, and will highlight the most immediate opportunities to improve the delivery, efficiency and effectiveness of policy.

Demonstrating improvements in biodiversity status at local, regional and national scales will enable us to protect New Zealand's natural landscapes, facilitate appropriate development, and meet international obligations to care for our unique plants and animals.

Impact 1:

Trends in national and regional biodiversity on public and private land are understood and based on best available descriptions for species and comprehensive indices of ecological integrity.

| KPI 1 | Progress |
|---|--|
| <p>DOC and regional councils are using comparable metrics to measure status and trend and impacts of interventions on biodiversity within their jurisdiction.</p> | <ul style="list-style-type: none"> Regional Councils (through the Biodiversity Forum) and DOC (through their Planning, Monitoring and Reporting Unit) are adopting the Ecological Integrity Concept, and its biodiversity metrics As a basis for determining status and trend, regional councils and DOC began using these Ecological Integrity metrics in their reporting, including in DOC's 2011/12 Annual Report |

Impact 2:

The most threatened ecosystems, habitats and species can be managed to reduce the risk of decline in native biodiversity.

| KPI 2a | Progress |
|--|--|
| <p>Consents related to land-use change under the Resource Management Act (RMA) are informed by a scientifically-based set of criteria that take account of cumulative effects on habitat availability.</p> | <ul style="list-style-type: none"> Cumulative effects of land-use intensification on highly-threatened dryland ecosystems in inland eastern South Island were a criterion used by the Environment Court and the High Court in four current hearings considering resource consents for major land-use changes The 'Upper Waitaki Shared Vision' collaborative forum of landowners, businesses and public interest groups reached agreement that 100 000 ha of new protective management of habitats is required in the Upper Waitaki (Mackenzie) Basin Applying the IUCN's ecosystem Red-List criteria, which are based on changes in ecosystem extent (i.e. habitat availability) and reductions in ecosystem processes, to New Zealand's 72 naturally uncommon ecosystems identified 18 critically endangered, 17 endangered and 10 vulnerable ecosystem types |
| KPI 2b | Progress |
| <p>Management decisions by DOC, MPI and regional councils, aimed at reducing threats to species and habitats, are based on robust risk models that reflect best available knowledge about the efficacy, cost and acceptability of management strategies and tools.</p> | <ul style="list-style-type: none"> A novel framework, which links species extinction rates to changes in both spatial distribution and population size, provides a potential common platform for end-users (such as sanctuary initiatives and DOC) to compare the expected outcomes (such as changes in overall species security) of different actions that change species habitat area and/or alter <i>in situ</i> population sizes. Updated threat listings of plants, fungi and terrestrial invertebrates are enabling DOC to reallocate resources for managing the most critically threatened species DOC and 14 regional, district and city councils have ranked their top ten environmental weeds using a risk model based on impacts and difficulty of control |

Highlights

Impact 1: The status and trends of land resources and ecosystem services (including their interactions) are known and understood.

A biodiversity assessment system for New Zealand

We have designed the first objective biodiversity assessment system where ecological integrity can be measured consistently and without bias at national and regional scales, on both private and public lands across conservation and productive landscapes.

Ecological integrity embodies three components – indigenous dominance; species occupancy; and ecosystem representation – and for each we worked with DOC to assess vegetation structure and composition, bird communities, and introduced mammal abundance and distribution at each of 80 indigenous forest sampling points, using an 8-km grid. These sampling points were a subset of the 1177 sites used for determining national-scale carbon stocks for MfE and for Montreal Process reporting by MPI; and hence is a cost-effective whole-of-government approach. As the DOC programme expands to all 1177 sites and beyond, we will be working with them to assess the effects of DOC management on ecological integrity. For example, vegetation structure results so far show widespread regeneration of palatable trees that have been eaten by deer and goats. An important implication is that deer and goat control can be targeted on the relatively few sites where regeneration is deficient and so recommendations from the New Zealand Game Council could be consistent with conservation outcomes.

The Regional Council Biodiversity Forum has now adopted the same objective biodiversity assessment framework. The framework is also attracting increasing attention from private sector groups, e.g. Future Forests Research, for reporting environmental performance and meeting product certification requirements.

This research was supported by Core funding, DOC, Envirolink, and regional councils. More information: www.landcareresearch.co.nz/publications/innovation-stories

Conservation status of native species

The New Zealand Threat Classification System, sponsored by DOC, is used to assess the threat status of New Zealand taxa (species, subspecies, varieties and forma), with the status of each group reviewed triennially to help guide conservation efforts. We contribute systematics knowledge of fungi, plants and invertebrates, including authoritative up-to-date names of threatened and at-risk species, and information on their distribution, abundance and biology.

‘Threatened’ and ‘at risk’ species are the basis of the DOC Species Optimisation project designed to maximise the value gained from resources committed to protecting threatened species. The Threat Classification System is also used by other agencies, e.g. MfE for state-of-the-nation biodiversity indicators.

The 2012 review of vascular plants added about 40 taxa to the ‘nationally threatened’ category (total now about 220 taxa). This significant change is largely due to the decline in ephemeral wetlands and partly due to identification of new species that have been designated ‘nationally threatened’. A large number of invertebrate species have also had their threat rankings changed, again partly due to newly discovered species. Thanks to targeted research, we have moved 112 fungal taxa from the ‘data deficient’ lists.

This research was supported by Core funding, DOC and TFBIS. More information: www.landcareresearch.co.nz/publications/innovation-stories

Status of Naturally Uncommon Ecosystems

The International Union for Conservation of Nature (IUCN) has proposed a quantitative approach to ecosystem-risk assessment based on changes in extent of ecosystems and reductions in ecosystem services. By applying the IUCN’s ecosystem Red List criteria to New Zealand’s 72 naturally uncommon ecosystems, we identified 18 ‘critically-endangered’, 17 ‘endangered’ and 10 ‘vulnerable’ ecosystem types. Naturally uncommon ecosystems contain

145 (85%) of mainland New Zealand's taxonomically-distinct 'nationally critical', 'nationally endangered, and 'nationally vulnerable' plant species, 66 (46%) of which were endemic to naturally uncommon ecosystems.

The results of this work have been used as evidence for Environment Court hearings on the Mt William North and Escarpment Mine coal mining proposals; to inform the development of the Regional Council Terrestrial Biodiversity Monitoring Framework; and in regional councils' environmental management plans and risk assessments.

International recognition of our research led to our involvement in the IUCN working group that is developing an Ecosystems Red List similar to the IUCN Species Red List.

This work was supported by OBI funding (now Core funding).

■ New Zealand Organisms Register (NZOR)

The NZOR project commenced in 2009 to create an accurate, authoritative, comprehensive and continuously updated catalogue of taxonomic names of all New Zealand biota and other taxa of importance to New Zealand. It was formally launched in August 2012 by the Minister for Primary Industries.

The knowledge of what organisms we have in New Zealand (and what we don't have) is fundamental to monitoring, reporting and critical decision-making in biosecurity, conservation and biodiversity research. We have led the development of the multi-agency, collaborative web-based framework to aggregate, integrate, share and continually update data from a range of authoritative sources. Sources include the plant, fungi, bacteria and invertebrate names databases associated with the Nationally Significant Collections that we manage, and data from the recently completed New Zealand Inventory of Biodiversity with contributions from NIWA, Te Papa, DOC, universities and a global team of 237 specialists.

NZOR currently collates basic data on 70 000 species present in New Zealand, and another 15 000 of importance. It is the most complete digital catalogue of any country, and the NZOR infrastructure is unique. It represents a significant national contribution to global efforts, led by the Global Biodiversity Information Facility (GBIF) and Group on Earth Observations Biodiversity Observation Network (GEO BON), to support evidence-based reporting of the status and trend of biodiversity globally.

NZOR is also part of an emerging standards-based biodiversity informatics infrastructure for data sharing and is the first regional dataset to be incorporated into the Global Catalogue of Life. (www.catalogueoflife.org)

NZOR is supported by TFBIS, and uses data in Core-funded Nationally Significant Collections and Databases. www.nzor.org.nz

■ New Zealand Virtual Herbarium (NZVH)

We led the development of the NZVH, launched August 2011. It provides free Internet access to over 700 000 records held in 11 botanical collections from Auckland to Dunedin. The records relate to over 1.4 million specimens of mosses, lichens, liverworts, ferns, algae and seed plants that have been collected in New Zealand from 1769 (Captain Cook's first voyage) to the present day; and cover all regions of the New Zealand mainland, as well as the offshore islands. These records can now be searched simultaneously across the participating herbaria and results viewed as distribution maps or for download. This will benefit conservation and biosecurity users of herbaria, including DOC, MPI, regional councils and researchers.

The work was supported by TFBIS, and uses data in our Core-funded Nationally Significant Collections and Databases. www.virtualherbarium.org.nz

Impact 2: The most threatened ecosystems, habitats and species can be managed to reduce the risk of decline in native biodiversity.

Understanding species extinction processes

Estimating rates of extinction associated with habitat loss is one of the most pressing tasks facing conservation scientists in the 21st century. In collaboration with a postdoctoral researcher at York University (Toronto, Canada), we have developed a new framework linking extinction to changes in species' distributions and changes in species' populations in time and space. They show for the first time how different disciplines in conservation science (genetics, population ecology, and fragmentation) can be united to provide more precise and context-specific estimates of extinction.

This work was supported by Core funding.

Dryland biodiversity

The spread of land-use intensification across the Mackenzie Basin floor in the last decade probably represents the most rapid rate of indigenous ecosystem loss and landscape transformation within any single ecological region in New Zealand in recent times. The basin is biogeographically distinctive, containing extensive and intact sequences of naturally rare terrestrial ecosystems that are strongholds for several of New Zealand's most endangered plant species. It also supports endemic and highly threatened invertebrate and freshwater fish fauna, and internationally important populations of threatened migratory wading birds, gulls and terns. Current protected land areas, which cover only 6% of the basin floor, are inadequate to maintain the viability of these ecosystems.

Our recent research includes measurement of land use changes and the remonitoring of the ~1000-ha Tekapo Scientific Reserve, which is the only sizeable area where stock have been absent and rabbits and wilding pines controlled to low levels for nearly 20 years. There is an astonishing resurgence of tussocks and other palatable native species in the absence of grazing across a variety of land forms and habitats. Dozens of tiny cryptic native plants, including several rare and uncommon species,

are showing similar resilience. This research has been presented at public meetings, deliberations, and hearings surrounding intensive agricultural development in the basin. Most recently, our research was used by the Upper Waitaki Shared Vision Forum of landowners, businesses and public-interest groups to reach an agreement to ask Government for funding for a substantial area (100 000 ha) of new 'protective management' in the Upper Waitaki (Mackenzie) Basin.

Funding has been provided by The Miss E.L. Hellaby Indigenous Grasslands Research Trust, Core funding and DOC.

Wetland restoration: adding value to land & water

New Zealand wetlands sustain indigenous biota, maintain water quality, sequester carbon and thus provide large economic, social and cultural benefits. Ecosystem services from wetlands have been valued at NZ\$34,184 per hectare per year. In spite of this, more than 90% of pre-settlement wetlands have been lost. Wetlands are complex systems driven by many interacting physical, chemical and biological processes, and this complexity has hampered restoration efforts in the past.

We worked with NIWA, DOC and the University of Waikato to produce a user-friendly manual of guidelines, techniques and tools to improve the management and restoration of wetlands. The manual is supported by extensive research including experiments in wetlands that have been drained, burned, mined, invaded by weeds, or otherwise modified. We developed a strategy to successfully restore a type of rare and threatened bog (*Sporadanthus*) at a site being mined for horticultural peat. Our patch restoration approach improved nutrient balances leading to better growth rates, better decomposition patterns and increased storage of carbon. Under our guidance, populations of *Sporadanthus* and rare invertebrates have been reintroduced to three privately-owned wetlands in the Waikato where the bog type once occurred. These wetlands are being showcased for visitors and educational purposes; and one is the site for the National Wetland Trust's proposed national wetland centre.

This research was supported by MBIE contestable funding, DOC, Envirolink, regional councils and other stakeholders. More information: www.landcareresearch.co.nz/publications/innovation-stories

■ Invasive species management

Invasive species management helps conserve localised populations and ecosystems, but rarely has its potential benefits been explored at the landscape scale. We have been investigating this in a series of related projects. The latest project involves DOC, Hawke's Bay Regional Council, community groups and the Robertson Foundation Aotearoa. Boundary Stream Mainland Island has had pest control for 15 years. It is surrounded by other reserves and many smaller privately-owned blocks of native habitat. However, these all sit within a 'sea' of unprotected agricultural land. We have begun applying 'metapopulation' management across thousands of hectares to determine if predator control in the pastoral landscape is sufficient to boost native species, using the network of native forest remnants. Models of connectivity between patches will help managers and community groups with limited budgets decide where and when to carry out landscape-scale pest control.

This research was supported by Core funding, DOC, Envirolink, Hawkes Bay Regional Council and the Robertson Foundation. More information: www.landcareresearch.co.nz/publications/innovation-stories

■ Choosing the 'best' weeds for biocontrol

Biocontrol can provide permanent cost-effective weed control. But worldwide only around one-third of programmes achieve effective control and one in six fails to have any impact. We have developed a three-factor framework to evaluate the potential cost and feasibility of biocontrol to help ensure projects are adequately resourced and agency expectations are appropriate.

First, all DOC conservancies and 14 regional, district and city councils ranked their top 10 environmental weeds according to perceived impacts and difficulty to control. We then used a database of the quantitative impacts of biocontrol against 80 weed species worldwide to assess traits that influence biocontrol success. These traits include whether or not a weed is also a major weed in its native range; mode of reproduction (sexual or asexual); and ecosystem type (aquatic/wetland or terrestrial). Targeting weeds that have already been successfully controlled by overseas agencies greatly reduces development costs. Impact, feasibility and cost rankings were combined to



Corinne Watts and Danny Thornburrow taking a break from searching prickly gorse for giant Mahoenui weta for translocation

give an overall 'priority for biocontrol' score for the 50 worst New Zealand environmental weeds. *Tradescantia* was top of the list – it had a high feasibility score, and is currently a biocontrol target in New Zealand, as is Japanese honeysuckle, second overall. However, within the top 20 weeds, eight species (40%), including the Chilean flame creeper and African club moss (ranked third and fourth), are not current biocontrol targets in this country.

Rankings should also be regularly reviewed. Some pragmatic decision-making will always be needed, particularly when deciding the right balance between weed importance and the feasibility of biocontrol.

The National Biocontrol Collective used the prioritisation system to help decide which projects to fund in 2012/13. We have also used the system to rank weed biocontrol targets in the Pacific region, and CABI have used it for weeds of Brazil and China. Weeds that affect the productive sector may also be included in the future.

This research was supported by Core funding, and builds on a Land & Water Australia pilot study. More information: www.landcareresearch.co.nz/publications/innovation-stories



OUTCOME 2

LAND RESOURCES

Sustainable use of land resources and the ecosystem services across catchments and sectors



► Rationale

Land resources include the soil's dynamic physical, chemical and biological 'systems', and the land cover, topography and hydrology in which the soil is situated. Land is a vital natural asset that supports a wide variety of resource use and which provides a wide range of ecosystem services, e.g. clean water, fertile soils, and aesthetic, cultural and spiritual benefits upon which New Zealand's economy, identity and brand are based. Our soil resources alone are estimated to underpin 25% of New Zealand's GDP.

Protecting our land assets does not automatically imply limiting resource use; rather it focuses on how resources

are allocated and managed for primary production, clean water, urban development, conservation, tourism and cultural values. Our land assets also underpin New Zealand's contributions to global issues (e.g. biodiversity loss, climate change). Effective management requires improved knowledge of their variability and change over time and across catchments and landscapes (natural, managed and urban), the impact of human activities, and potential environmental limits.

Achieving appropriate sustainable management of our land and water resources is a major economic development opportunity for New Zealand.

Impact 1:

The status and trends of land resources and ecosystem services (including their interactions) are known and understood.

| KPI 1 | Progress |
|--|---|
| <p>LCDB (land cover), LUDB (land use), S-map (soil) and ESDB (ecosystem services) components of LRIS (Land Resource Information System) have been enriched and are being used under the New Zealand Government Open Access Licensing framework for web-services.</p> | <ul style="list-style-type: none">• S-map Online now provides land managers, consultants and other researchers with a detailed level of spatial information to help fine-tune land management and technologies• An updated version of the Land Cover Database, a thematic classification of land cover (33 classes in LCDB v3.0), has been released• Where appropriate, information from our Nationally Significant Databases is available online under an open-licensing agreement whereby the data are freely used for public good (non-commercial) purposes provided Landcare Research is acknowledged as the source of data |

Impact 2:

Opportunities and threats to land resources are recognised and balanced to maintain or enhance the provision of ecosystem services.

| KPI 2a | Progress |
|--|---|
| <p>Regional councils and the irrigation, pastoral, horticultural and arable sectors are using knowledge of soil variability to improve the match between land-use practices and land capability.</p> | <ul style="list-style-type: none">• Precision irrigation tuned to soil variability at the paddock scale has achieved water savings of 20–36%, without any reduction in productivity, at three demonstration farms• Gisborne, Hawke’s Bay and Southland councils now have access to significantly improved S-map coverage of soil variability• Soil variability underpins the design and storage capacity of effluent management systems that comply with DairyNZ’s code of practice |

Highlights

Impact 1: The status and trends of land resources and ecosystem services (including their interactions) are known and understood.

The National Land Cover Database (LCDB)

Landcare Research was commissioned to deliver two new editions of the Land Cover Database (LCDB) alongside a parallel research programme to develop improved ways of generating land cover information from satellite imagery. The LCDB series is a significant and authoritative resource of national land cover data and one of only a few datasets providing data at approximately 5-yearly intervals for describing change. It underpins state of environment monitoring, forest and shrubland inventory, biodiversity assessment, trend analysis and infrastructure planning, making it an invaluable tool for policymakers and land managers. Recent work has focused on improving data reliability and the technology for their delivery. The LCDB Governance Body comprises MBIE, MfE, LINZ, DOC, MPI and regional councils).

Version 3 (LCDB3) was released in July 2012 – a highly significant achievement that has been eagerly awaited by many stakeholders. LCDB3 maps land cover as at 2008. It includes new satellite data acquired during 2008/09; corrections for earlier errors; improved line-work representations; and responds to the needs of regional councils, territorial authorities and DOC. The project has also attracted the attention of Korean scientists and politicians looking to establish national datasets to facilitate climate change mitigation and reporting in Korea.

LCDB4 will be derived from 2012 remote sensing data. The goal is that by 2015 end-users will have access to a well-established series of LCDB editions that provide the authoritative record of land cover and land cover change in New Zealand.

This work was supported by MBIE contestable funding, with considerable in-kind support from DOC and regional councils. <http://lris.scinfo.org.nz>

S-map Online

Soils are inherently variable. Knowledge of this variability enables fine-tuning of land and water management for economic gain and more sustainable resource use. Our S-map database was updated throughout the year – funding from Envirolink and regional councils allowed coverage to be extended in areas of the Wairarapa, Hawke's Bay, Gisborne, Canterbury, and the West Coast.

S-map shows what soils occur where, and what their properties are. Soil variability significantly affects water storage, nutrient leaching and plant productivity, and S-map allows all this to be expressed as online maps. S-map also delivers soil information to a multitude of users (farmers, sector groups, consultants, government agencies) either directly to their geographic information systems or through our user-friendly portal, 'S-map Online'. Accurate soil data underpin more sophisticated computer modelling, including the setting of reasonable water quality targets. S-map provides critical information to support nutrient management tools (such as Overseer), specialist crop calculators (such as for wheat and potatoes), and the dairy effluent soil risk calculator.

The dividends of tuning management to soil variability are exemplified by a catchment-scale case study in the Mataura Valley, which showed a cost-benefit ratio of 1:6 in the first year. Focusing mitigation practices on stony soils under dairy land use saved farmers \$17 per kilogram of nitrogen (kgN) applied, and benefitted the community by \$25 per kgN applied through reduced leaching to groundwater.

Knowledge of soil differences is also being used by some regional councils to set compliance regulations for irrigation scheduling. For example, Environment Waikato is investigating the use of soil water balance models for individual soil types to improve accuracy and allocation of freshwater consents for irrigation. Environment Canterbury

also allocates freshwater consents for irrigation assisted by knowledge of the likely soil types and their available-water-holding capacities.

This research was supported by Core funding, Envirolink, regional councils and other stakeholders. More information: www.landcareresearch.co.nz/publications/innovation-stories

■ Our Environment online

The past year has been a period of increased engagement with stakeholders, and improved access to our data and new information via several online 'tools'. These easy-to-use tools support improved monitoring and management of ecosystem services, soil conservation programmes, land use decision-making, and education. In addition to S-map Online, we launched Our Environment, which is another new web-based interactive application that draws on Landcare Research's considerable holdings of environmental data. The application makes it possible to view maps, query features shown on the maps, and follow links to explanatory information. It covers landscape features (e.g. slope, aspect, erosion), land use capability (e.g. arable cropping, land-use intensification, production forestry), and ecosystems and habitats (e.g. vegetation types, threatened ecosystems and legally protected areas). The thematic focus is designed to make it easier for the general user although experts should find it of value too.

This work was supported by Core funding and provides access to Core-funded databases. <http://ourevironment.scinfo.org.nz/>

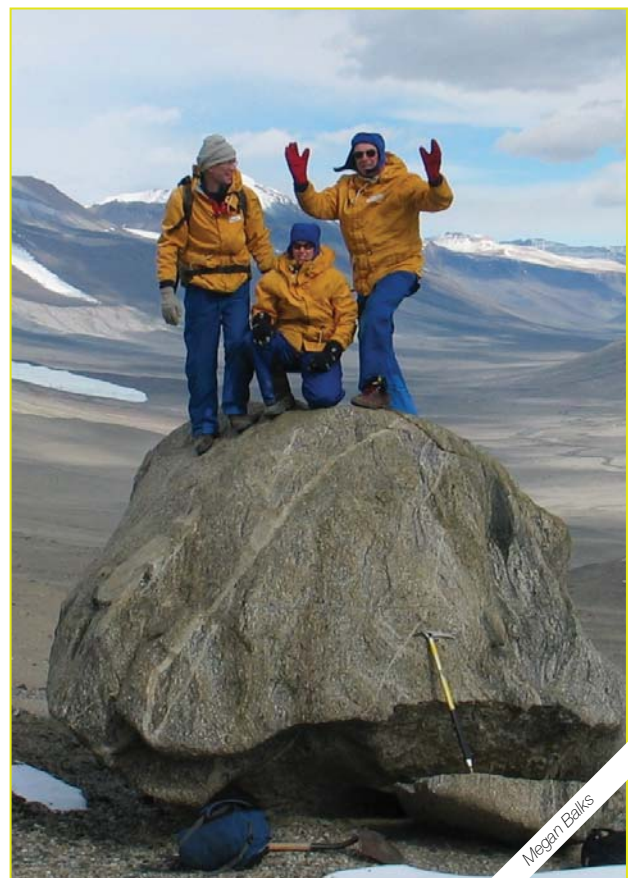
■ Environmental Domains for the Ross Sea Region of Antarctica

Landcare Research is working closely with Antarctica New Zealand and the New Zealand Antarctic science community to develop and refine an environmental classification for the Ross Sea Region of Antarctica. Developing the classification relies on collation of all available high-quality climate, ice cover, landform, geological, soil, and biological information. These data layers are then evaluated through the classification process (known as an environmental

domains analysis) to generate a spatial classification that allows similar environments (including distinctive environments that are otherwise easily overlooked at the continental scale) to be grouped based on environmental character regardless of geographical location.

In addition, we are developing a geospatial data portal to ensure the data and classifications are accessible to all Antarctic stakeholders. The classification and data portal will improve Antarctica New Zealand's ability to monitor, report, and manage the region and fulfil New Zealand's obligations under the Protocol on Environmental Protection to the Antarctic Treaty.

This work is supported by MBIE contestable funding.



Soil scientists in the dry valleys of the Ross Sea Region of Antarctica

Impact 2: Opportunities and threats to land resources are recognised and balanced to maintain or enhance the provision of ecosystem services.

Māori Land Visualisation tool

Landcare Research has made steady progress on refining the prototype Māori Land Visualisation tool. This enables Māori land owners to gain a better understanding of the characteristics of their land assets and their potential use, and helps build knowledge and capacity to practice kaitiakitanga across their lands.

This year, the main focus has been further technical development (adding map layers and improving content) and creating a governance entity including representatives from Te Puni Kōkiri (TPK), the Office of the Māori Trustee, Ministry of Justice and the Māori Land Court, LINZ and MPI. Governance issues include strengthening stakeholder engagement and support, where to 'host' the online tool, tailoring the tool to end-users, and developing a business model to seek long-term funding. The aim is to take the tool from a prototype model to a client-driven sustainably-funded tool.

This work was supported by TPK with some internal investment; some of the databases accessed are Core-funded.
<http://whenuaviz.landcareresearch.co.nz>

Water quality issues for regions

Regional councils are charged with managing the cumulative effects of land use on water quality. In collaboration with Environment Canterbury, we have developed new tools to assist land managers in meeting water quality limits for the region.

In a simulated study, we showed that current methods and technology for measuring leachate under grazed pasture are woefully inadequate. Impractical numbers of measuring devices are required to accurately estimate average leaching from a field. This is of critical importance given this type of data is used by researchers to develop and evaluate farm-scale leaching models, and some regional councils are hoping to ensure compliance with nutrient discharge limits through such measurements.

The spatial model AquiferSim (developed with Lincoln Ventures) assesses the impact of potential land intensification options on water quality in aquifers and spring-fed streams; this takes only minutes (rather than weeks as with more complex models). It can be used where geo-hydrological data are limited (good information is only available for a few aquifers in New Zealand). We tested AquiferSim in the Central Canterbury Plains (where there are good data) and in the Hurunui (where there are only poor data). This modelling work contributed to the Environment Canterbury's Land Use and Water Quality Project, a collaborative process with stakeholders that resulted in the Hurunui and Waiau River Regional Plan. We are now working with Environment Southland to apply AquiferSim to the mid-Mataura Basin.

Our new spatial model of contamination risk at the regional scale draws on data in S-map and relevant research on contaminant pathways. This helps land managers determine where mitigation practices are needed, and enables regional councils to apply more appropriate consenting rules for effluent disposal and septic-tank-discharge fields. We used an updated regional nitrate-leaching map to provide statistics on the impact of nitrate thresholds being considered for the draft Canterbury Land and Water Regional Plan. We also developed a new method for allocating a catchment-scale nutrient limit between farms. This focuses on more intensive mitigation practices for land where there is a nitrate contamination problem, i.e. intensive land use on leaky soils in catchments known to have poor water quality.

This research was supported by Core funding and Environment Canterbury. More information:
www.landcareresearch.co.nz/publications/innovation-stories

National ecosystem services trends

Our economy and well-being rely on ecosystems and the services they provide, such as food and fibre, water regulation and pollination, recreation and tourism, and soil formation and nutrient cycling. We are undertaking research with a wide range of stakeholders to characterise the condition and trend of ecosystem services across all regions of New Zealand, and to look at how the full range of these services should be incorporated within decision-making on land use, development and management.

Several trends have emerged, highlighting areas for future research or policy focus.

- 1 Ten percent of high class land in New Zealand is occupied by lifestyle blocks; 0.5% of high class land has been urbanised in the last 20 years
- 2 Nitrate inputs to fresh water are increasing in Canterbury, the West Coast, and Southland. They are decreasing in Manawatu-Wanganui, Northland, Bay of Plenty, and Auckland. Elsewhere they are remaining the same
- 3 Climate-regulation services provided by natural ecosystems are of a similar order of magnitude to fossil fuel emissions
- 4 Over the last 20 years 51 000 ha of indigenous forest has been cleared and 71 000 ha of tussock grasslands has been converted to exotic pasture

We work with and report to a stakeholder group consisting of regional councils, MfE, MPI and DOC. On a one week-long tour of regional councils in the North Island, we presented our work on scaling up greenhouse gas emissions and carbon storage to national scale, and discussed our framework for assessing the impacts of land-use change on greenhouse gas and other ecosystem services. Regional councils are interested in the information for communicating, educating, reporting and monitoring following land-use changes.

This research was supported by Core funding. More information: www.landcareresearch.co.nz/publications/innovation-stories



Mike Marden excavating tree roots with an air gun; part of research into erosion control

| Important services from managed ecosystems | Important services from natural ecosystems |
|--|---|
| Food: crops, livestock, aquaculture Fibre: timber and wood fibres, others Biomass fuel Fresh water Genetic resources Minerals | Food: capture fisheries, wild foods Fibre: timber and wood fibres Fresh water Minerals |
| Regulation: climate (global), water, erosion, pests, natural hazards, disease Water purification and waste treatment Pollination | Regulation: climate (global), water, erosion, pests, natural hazards |
| Spiritual and aesthetic values, sense of belonging Recreation and tourism | Spiritual and aesthetic values, sense of belonging Recreation and tourism |
| Soil formation and maintenance | Soil formation and maintenance Provision of natural habitat free of weeds and pests |



OUTCOME 3

GREENHOUSE GASES

Improved measurement and mitigation of greenhouse gas emissions from the terrestrial biosphere

► Rationale

New Zealand must meet its international greenhouse gas reporting obligations and decrease net emissions of greenhouse gases from terrestrial systems to below 'business as usual' levels. To achieve this, it is necessary to have (1) a robust inventory of net emissions and carbon storage and (2) effective mitigation options for reducing net emissions. Changes in emissions and carbon storage as a consequence of management, land use and global change can then be forecasted and appraised. New Zealand is required to produce an annual inventory of greenhouse gas emissions under the UNFCCC (United Nations Framework Convention on Climate Change).

While there has been a lot of research effort to estimate changes in above-ground carbon storage in vegetation with land-use management, much less is known about the effects on soil carbon storage. Although New Zealand's commitment to reduce net greenhouse gas emissions

does not include changes in soil carbon storage, we are required to report such changes annually in relation to land management and land-use change.

Research is needed to develop new methodology for measuring soil carbon storage and for reducing uncertainty for estimating and scaling emissions, and quantifying changes in emissions as a consequence of key land-use and management change. This will allow mitigation strategies to be developed and approaches for increasing carbon storage to be identified and adopted. This is an area in which the science challenges are substantial and we are developing new national and international collaborations to address them. We have a significant role to play and are acknowledged internationally for our expertise in carbon and nitrous oxide science.

Impact 1:

Terrestrial greenhouse gas emissions and removals are understood and quantified so that changes in relation to management strategies, land-use policies and global change can be predicted.

| KPI 1 | Progress |
|---|---|
| <p>MPI and MfE are using verified estimates of greenhouse gas emissions and carbon storage to reduce uncertainty in national inventories.</p> | <ul style="list-style-type: none">• Afforestation was greater than deforestation (579 000 ha \pm 2% and 75 000 ha \pm 6% respectively) in New Zealand between 1990 and 2008. The difference gave MPI an estimate of carbon emissions due to forest changes• Modelling the growth of pine forest and kānuka/mānuka stands is providing MPI with carbon sequestration rates and data on how these vary regionally and temporally• The uncertainty in estimating soil carbon for perennial croplands in MfE's Soil Carbon Monitoring System has been significantly reduced |

Impact 2:

Strategies for land use and asset management increase carbon storage, mitigate greenhouse gas emissions and balance environmental, economic and social benefits.

| KPI 2 | Progress |
|---|--|
| <p>Agricultural land managers and DOC are, where appropriate, using validated methodologies and land-use practices to mitigate greenhouse gas emissions and increase carbon storage and adapt to likely climate change effects.</p> | <ul style="list-style-type: none">• The effectiveness of the nitrification inhibitor DCD in reducing nitrous oxide emissions from stock effluent can now be optimised for use by agricultural land managers• Land managers have an improved basis for incorporating variability in carbon stocks when planning emissions management for natural forests |

Highlights

Impact 1: Terrestrial greenhouse gas emissions and removals are understood and quantified so that changes in relation to management strategies, land-use policies and global change can be predicted.

Modelling future forests growth

How fast can different forests grow now and under future climates? These are important questions both in terms of current and future wood supply for the forestry industry, and for assessing the potential of our forests to sequester carbon to mitigate climate change. Past assessments using empirical modelling to provide national growth estimates have limited scope and reliability for future predictions.

In collaboration with the CRIs NIWA and Scion, we customised and refined an Australian physiologically-based approach to modelling wood volume growth and carbon storage for *Pinus radiata* and indigenous kānuka /mānuka stands, two important and diverse forest types in New Zealand. We tested the model against a wide variety of measurements (e.g. short-term daily fluxes of water and carbon exchange through to growth rates assessed and measured over years and decades) and across a wide range of environmental conditions.

This provided a robust and physiologically-based description of *P. radiata* productivity under current conditions in New Zealand and its likely response to climate change. Stand growth in carbon sequestered ranged from about 10 tC/ha/yr in the fertile, warm, wet western half of the North Island to only 2–4 tC/ha/yr in Central Otago and Canterbury and no growth at all at higher altitudes of the mountains of the South Island. Regional growth patterns were similar for kānuka /mānuka, but maximal biomass growth rates were only about 2 tC/ha/yr in the most fertile regions and about 1 tC/ha/yr in regions with more adverse environmental conditions. These differences between the stand types were mainly attributable to carbon losses from self-thinning in moderately young kānuka/mānuka stands, and a slowing of growth rates in older stands as trees have to increasingly compete with later-successional species that

eventually replace kānuka/mānuka stands leading to a loss of the carbon initially stored by those trees.

Temperature is often a limiting factor to growth. With climate warming, stands are likely to increase their growth potential over much of the cooler parts of the South Island and at higher-elevation sites on both islands. In contrast, there are likely to be growth reductions in warmer parts of the country or in drier regions, such as the east coast of both islands, where even moderate warming can intensify existing water limitations. However, even these limitations could be overcome through plant response to increasing atmospheric CO₂ concentration, provided plant responses will be as strong as currently anticipated based on a limited range of experimental observations.

This research was supported by Core funding and MPI-SLMACC funding grants. More information:
www.landcareresearch.co.nz/publications/innovation-stories

Pasture to shrublands, the impact of land-use change on carbon storage

As pastoral grazing is abandoned in many marginal areas of New Zealand, native woody vegetation is reinvading and regenerating. Knowledge about changes in carbon stores can be used to reduce our carbon liability, and while the modelling work described above incorporates such research, some aspects need refining through further research such as in this project.

In a well-watered pastoral site retired from grazing in North Canterbury, we measured the carbon gain each year. In the first six years, above-ground carbon increased by at least 10 times, but it was very labile and fluctuated seasonally.

The major species that regenerates naturally on abandoned pasture are kānuka/mānuka ('shrubland'), and although we know a lot about the mature shrubland on older abandoned lands, there is little information on the early stages of growth, which can be slow. It may take six years until the carbon stored in the trees equals that stored in the grass. But since the growth is exponential, carbon storage quickly increases in the next six years. After four years the amount

of carbon in the soil to a depth of 0.3 m has decreased by 9%, mainly due to the decrease in soil bulk density once compaction from stock ceased. Such small changes are difficult to detect and there is considerable spatial variability, but understanding the processes regulating soil carbon dynamics is critical for forecasting future carbon stocks.

These results can now be used for carbon accounting to take into consideration the changes in New Zealand land use. They can also be used to model changes in carbon storage in the early phases of pasture abandonment and forest regeneration, to allocate carbon credits. These models can be employed for national-scale carbon estimates by the Ministry for Primary Industries (MPI) and thus effectively increase the precision of these estimates of carbon storage.

This research was supported by Core funding. More information: www.landcareresearch.co.nz/publications/innovation-stories

■ Impact of forest disturbance

We showed that forest disturbance is critical for regulating the balance between forests as long-term sources or sinks of carbon. A new model of carbon sequestration during forest regeneration demonstrated that a suite of disturbances (windthrow, earthquake, beetle outbreak) caused a small net loss of carbon (0.3 tC/ha/yr) in mountain beech over a 30-year measurement period.

This work was supported by MPI-SLMACC.

■ Nitrous oxide emissions

Nitrous oxide emissions are largely driven by livestock numbers, fertiliser use and farm management, and make up about 14% of our anthropogenic greenhouse gas emissions. Nitrous oxide emissions are of growing importance because of agricultural intensification, but have proven very difficult to estimate because they are highly variable over space, climatic conditions, land management and time. Direct measurement at a national scale is not feasible. New Zealand needs its own specific capacity to estimate nitrous oxide emissions so it can report accurately and develop and deploy technologies to reduce them.

We found that the nitrification inhibitor DCD applied to grazed pastures in the Manawatu can reduce nitrous oxide emissions from urine patches by 55% and also reduced nitrate leaching. Soil temperature is the major regulator for the breakdown of the inhibitor, with the inhibitor lasting longer in soils at lower temperatures. This suggests the effectiveness can be optimised by applying the inhibitor at different rates and frequencies for different seasons.

We improved the basis for estimating nitrous oxide emissions for poultry, and our work led to the adoption of a revised country-specific emissions factor from the default value for New Zealand. This has led to a reduction in emissions liability for the poultry industry by 50%. Through complementary research, we recommended a reduction in the New Zealand specific emission factor for ammonia (an indirect greenhouse gas emitted following the use of urease inhibitors applied with nitrogen fertiliser). This equates to a potential reduction of 47 700 tCO₂-e annually for New Zealand.

Our collaborative research with AgResearch has already led to improved estimates for nitrous oxide emissions from hill country pastoral farming, and is likely to significantly reduce the emissions liability of the sheep and beef sector.

This research was supported by Core funding (including capability), MPI, NZAGRC, PGgRc, Fonterra, DairyNZ, New Zealand Fertiliser Manufacturer's Research Association and Ballance Agri-nutrients, and is collaborative with Lincoln and Massey Universities. More information: www.landcareresearch.co.nz/publications/innovation-stories

■ DNDC model for New Zealand

We used field and laboratory data to develop a local version of the DNDC (denitrification /decomposition) nitrous oxide and methane flux model for grazed pasture under New Zealand's climate conditions, soils, pasture growth patterns, fluctuations in soil water, grazing regimes, and fertiliser and animal nitrogen inputs, including the effect of uneven spatial distribution of urine deposits. This NZ-DNDC model, applied at the regional scale (Manawatu), successfully showed where, and to what degree, emissions are a problem.

By running our NZ-DNDC model populated with 20 years' of climate data over a range of soil types, climatic conditions and farm management practices, we developed 'look-up' tables of direct nitrous oxide emission factors for New Zealand. We linked these calculations to a framework allowing us to estimate emissions at large spatial scales. Because this approach incorporates variability associated with soil and climate, it will improve estimates of agricultural nitrous oxide emissions at regional to national scales, and enable us to forecast the impacts of land-use-change scenarios.

This research was supported by Core funding, MPI and NZAGRC.

Impact 2: Strategies for land use and asset management increase carbon storage, mitigate greenhouse gas emissions, and balance environmental, economic and social benefits.

Partnering with the dairy industry

We initiated a 5-year project in partnership with Synlait to develop more precise techniques to measure emissions of agricultural greenhouse gases at paddock scales. Synlait is allowing us to use one of their Canterbury dairy farms and will provide relevant farm management records. We have installed and tested field instrumentation for simultaneous real-time measurements of the exchange of carbon dioxide, methane and nitrous oxide over an irrigated paddock and an adjacent non-irrigated site. Our measurements will start in spring and continue for the next five years.

This research is supported by Core funding and Synlait.

Methane mitigation

There is currently no technology available to manage methane emissions from the dairy-farm effluent ponds where energy capture is not an economic option. In a series of in vitro studies, we identified a suitable soil methanotroph (bacterium that 'eats' methane) population able to consume the high emissions typical of these effluent ponds. We built

a prototype methane biofilter by incorporating the most active and resilient methanotroph population in a volcanic soil matrix. This biofilter has been consuming >95% of the methane produced by an effluent pond on the Massey University dairy farm, with minimum maintenance for the last two years.

A second prototype, in which the filter is incorporated in the effluent pond cover, has also performed efficiently and does away with the need for the costly plumbing required by the first prototype. This research has brought us much closer to designing a practical, low-cost biofilter. It shows that, by incorporating active methanotrophs in a floating artificial island made from recycled plastic bottles and supporting wetland plants, we could not only capture methane but also remove nutrients to produce harvestable biomass.

This work is supported by MPI-SLMACC and is collaborative with colleagues from Massey University; University of Victoria, Canada; University of Western Sydney.

High country carbon

We know very little about the size of ecosystem carbon stocks and carbon fluxes associated with low-intensity pastoral grazing in New Zealand non-forested high country lands. Landowners and managers have few options for mitigating and offsetting greenhouse gas emissions (exotic afforestation may be inappropriate or of limited viability). In a collaborative project, we assessed whether retiring land from grazing increases carbon sequestration. Results show that retiring land from grazing has negligible effect overall on carbon stocks, even after at least a decade. The largest changes occurred in the smallest pools of carbon (i.e. plant mass and litter). The extensive grazing regimes produced smaller differences in ecosystem carbon storage than the variation that occurs naturally across different sites. These results contrast with those from other agricultural lands (cropland, dairy land) where ongoing losses of soil carbon are associated with long-term land-use intensification.

This project was supported by the Sustainable Farming Fund and was collaborative with high country agricultural landowners, land managers and industry groups, local government and NGOs.

Carbon in cropping soils

Tillage of cropland soils results in losses of soil carbon, but the significance is highly dependent on the degree of disturbance. Our measurements at the Millennium Tillage Trial near Lincoln in collaboration with Plant & Food Research have shown that the degree of carbon loss following tillage of barley is dependent on the fraction of labile carbon in the soil. We used state-of-the-art techniques employing stable isotopes to partition carbon loss from soil and roots, without disrupting the system, to develop a new way to estimate losses of labile carbon. We compared this approach with more traditional, labour-intensive methods that use physical fractionation and found good agreement. Continuous tillage at our experimental site over a decade has resulted in a loss of labile carbon of 1%, compared with a loss of 0.4% in adjacent sites with no tillage.

This research was supported by Core funding.

Pasture quality from space

We are combining observational data and process-based insights from our research and databases in advanced models to improve estimates of greenhouse gas emissions integrated from small plots to catchments to the national scale – as has been described in preceding highlights.

We are also developing models to estimate pasture quality using remote sensing data from satellites in space. Pasture quality has an influence on methane and nitrous oxide emissions, and the current values used in the national greenhouse gas inventory are crude and inadequate. We are undertaking field sampling ('ground truthing') across various farm types and regions, and testing the capability of remote sensing to predict pasture quality for future monitoring. The sampling campaign has led to much improved spatial pasture-quality estimates for use in the national greenhouse gas inventory. The remote sensing research could improve cost-effectiveness in the future.

This research is collaborative with MPI, and was collaborative with AgResearch and On-Farm Research.



John Hunt setting up instrumentation at the Synlait Farms study site



OUTCOME 4

INDUSTRIES & ORGANISATIONS

New Zealand industries and organisations have increased ability to develop within environmental limits and meet market and community requirements

► Rationale

To achieve sustainable economic development, New Zealand must work within environmental limits and yet be responsive to the often-diverse needs of multiple stakeholders, including government and local government, the private sector, Māori and the community. Development is becoming increasingly complex with no 'right answer' for resolving high-risk and polarised viewpoints, such as those associated with global change, possum control to eliminate bovine TB (tuberculosis), and water quality and scarcity.

Research underpins effective environmental policy, and effective policy provides the framework for sound resource management decisions. Policy development processes are enhanced through (1) stakeholder engagement (to

understand preferences, values and governance options), (2) scientific information to support choices and decisions, and (3) adaptive management to evaluate and improve policy performance.

Primary production, trade and tourism are increasingly affected by community expectations and market demands for environmental responsibility and sustainable practices. Environmental integrity ('clean, green') is critical to the New Zealand brand. Managing possums and bovine TB is a significant trade compliance issue for New Zealand's animal industry. Our research is supporting AHB's mission to eventually eradicate the disease entirely, to increase New Zealand's competitiveness in overseas food markets.

Impact 1:

Approaches to resolving complex environmental issues are understood, and opportunities recognised for adapting to global change and reducing vulnerability to resource scarcity.

| | |
|--|---|
| <p>KPI 1</p> <p>Industry sectors, central and local government are making strategic use of research findings, associated indicators of performance, and new economic instruments to respond to complex environmental issues, global change processes and resource scarcity.</p> | <p>Progress</p> <ul style="list-style-type: none"> • The energy sector (Meridian Energy, Solid Energy and Buller Coal over this past year) is incorporating offset programmes and fit-for-purpose rehabilitation activities into their environmental management • The New Zealand Forest and Agricultural Regional Model (NZ-FARM) is being used to assess policy options for improving water quality and the economic impacts for meeting environmental limits • Our carbonZero^{Cert}™ programme (including CEMARS[®]) is being used by 138 New Zealand businesses and organisations |
|--|---|

Impact 2:

Integrated economic, social, cultural and environmental initiatives for business and industry are effective in maintaining or enhancing their international competitiveness, market access and social licence to operate

| | |
|---|---|
| <p>KPI 2a</p> <p>An industry sector (dairy, horticulture or energy) is using a framework for integrating economic, environmental, social and/or cultural drivers to meet community and/or market requirements.</p> | <p>Progress</p> <ul style="list-style-type: none"> • The World Resources Institute's Ecosystem Service Review methodology was applied to develop strategies for ZESPRI International to manage risks and opportunities arising from growers' dependence on ecosystems • Our Enviro-Mark[®] management system is being used by 180 member firms in the print, food production, and retail industries • A strategy for harvesting brushtail possum fur, while meeting forest conservation outcomes, was developed with a rural Tūhoe community |
| <p>KPI 2b</p> <p>Bovine TB (tuberculosis) is eradicated by the AHB from vector populations in two extensive forest areas in programmes responding to economic, social, cultural and environmental drivers.</p> | <p>Progress</p> <ul style="list-style-type: none"> • A quantitative framework has been developed for objectively assessing the probability that bovine TB has been eradicated from a specific forest area |

Highlights

Impact 1: Approaches to resolving complex environmental issues are understood, and opportunities recognised for adapting to global change and reducing vulnerability to resource scarcity.

Enhancing policy development

We are working closely with MPI, regional councils and other stakeholders to assess the likely environmental and economic impacts of climate change, land use change, and related policies. We have developed NZ-FARM – the New Zealand Forest and Agriculture Regional Model – which has already been used at catchment scale to assess policy options for improving water quality and reducing greenhouse gas emissions through changes in land management.

At the global scale, we are leading a collaborative project with AgResearch and Lincoln University to develop a trade-focused Integrated Assessment Modelling capability for New Zealand. This initiative will help government understand how climate policies and climate change may affect the global demand for and supply of primary commodities, which are vital exports for New Zealand.

Landcare Research has made a strategic investment in a partnership with the Computation Institute – a joint venture of the University of Chicago and Argonne National Laboratory in the US – using advanced computational techniques and facilities to develop high-resolution models of climate impacts and land use change. This work will support MFAT and other government agencies in international treaty negotiations and private sector business strategy.

The work is supported by Core funding, MPI-SLMACC and Landcare Research Strategic Investment.

Engaging business around ecosystem services

The World Resources Institute's Ecosystem Service Review methodology helps businesses develop proactive strategies for managing the risks and opportunities relating to their dependence on ecosystem services (e.g. for water) and their impacts on these. We have been the first organisation in New Zealand to apply the method successfully – in this

case, for ZESPRI International. The results are now being shared with a wide range of stakeholders such as DOC, MfE, Waikato Regional Council, and BusinessNZ with the aim of enhancing the understanding and actions of New Zealand businesses regarding ecosystem services.

This work was supported by Core funding and ZESPRI.

Biodiversity offsets

DOC has led a cross-departmental research programme in which we investigated the feasibility of biodiversity offsets in New Zealand. Offsets will help New Zealand to balance major economic development initiatives within a framework of no net biodiversity loss. The Programme has developed Best-Practice Guidance on Biodiversity Offsetting, which assesses both the biodiversity that would be lost under a development and the biodiversity benefits gained through compensation initiatives.

This year we were contracted by Meridian Energy to identify the vegetation and assess the impacts of their proposed dam on the vegetation values of the Mokihinui River gorge, and then develop a pest control plan for their proposed biodiversity compensation (offset).

We also helped develop a biodiversity offset proposal for a new coal mine (for Solid Energy, with Mitchell Partnerships). The proposal was intensively peer-reviewed by Tonkin & Taylor for West Coast Regional Council, and was presented at the Consents Hearing in mid-2012. This project, the Strongman Mine offset (Solid Energy) and the proposed Escarpment Mine offset (Buller Coal) focus on endangered species (kiwi, *Powelliphanta* snails) and threatened ecosystems. In each case, the approach to calculating the 'baseline' was relatively consistent. What differed markedly was the selection of a 'multiplier' – the value placed on 'trading up' or the 'in-kind' offset – and the value placed on cost-effectiveness of the offset. These projects offer a valuable practical insight into the hidden trade-offs that occur depending on how biodiversity is valued and which habitat-condition characteristics are selected, and how these skew offset projects towards pest control in specific ecosystems rather than revegetation of slow-growing, complex ecosystems.

Through our work with colleagues in Australia, USA, UK and South Africa (many of whom are associated with the international forum Business and Biodiversity Offsets Programme) we are contributing to development of global frameworks to assess when and where biodiversity offsets are suitable, and ways of depicting and mitigating uncertainty in design and delivery. This is enabling local approaches to be consistent with international best practice.

Impact 2: Integrated economic, social, cultural and environmental initiatives for business and industry are effective in maintaining or enhancing their international competitiveness, market access and social licence to operate.

Restoration forestry for Tūhoe Tuawhenua Trust

Podocarp trees were selectively harvested from Tūhoe Tuawhenua Trust forests in the 1960s and 70s and now the Trust wishes to restore these podocarps in their tawa-dominated forests. Over the last decade we have undertaken various studies in these forests, and this work is now contributing to understanding how podocarps might be restored. Research includes the regeneration requirements of podocarp seedlings in relation to site conditions and competition from other plant species, as well as growth and mortality in remaining podocarp trees. Clearly seedlings and saplings of rimu, formerly the dominant podocarp in these forests, require significant light gaps to grow and survive into the canopy. As a means of creating canopy openings that form conditions suitable for podocarp regeneration, the Trust has more recently trialled the use of timber harvesting. The extraction of tawa as a high-value timber offers a self-funding means of restoring the forest and creating employment opportunities. Using the results of our experimental studies and modelling, as well as their experience in tawa extraction, the Trust has recently submitted a Sustainable Forest Management Plan to MPI as the first step in operationalising the restoration of their forests. This is a community-empowering result from our collaborative research with the Trust.

This work is supported by MBIE contestable funding, MPI and Landcare Research investment.

Diagnostic tools for biosecurity

Accurate, rapid identification of organisms intercepted at the border and in post-border situations is critical to evaluating and responding to threats to New Zealand's agriculture, environment and economy. Threats include fruit flies, plant pathogenic fungi and bacteria, and plants very likely to become severe weed problems. Understanding the potential risk, and whether control or eradication is possible, facilitates appropriate and timely responses from MPI, local authorities, sector groups and other stakeholders.

Systematics research underpins development of new biosecurity diagnostic tools. For example, the fungus *Colletotrichum* is one of the top 10 most important disease-causing pathogens in the world but it is notoriously difficult to identify the species associated with each disease. We used cultures from the International Collection of Microorganisms from Plants (ICMP) to clarify the taxonomy and provide MPI and plant pathology researchers with a barcoding tool – a set of authentic DNA sequences from standard genes that allow accurate identification of a *Colletotrichum* species within hours of it being discovered.

We worked with ZESPRI and MPI to identify Psa as the bacterium responsible for the initial outbreak of kiwifruit vine canker affecting Bay of Plenty orchards. Since then, we have analysed samples from 61 orchards (over 2400 leaves surveyed) – first by culturing the causal bacterium, followed by DNA sequencing to determine the within-species 'pathovar', and within that the particular strain of concern.

Among other recently-developed diagnostic tools (freely available online) for invertebrates and for plants, our weeds key is now routinely used by regional council biosecurity officers to identify banned garden plants at nursery inspections.

This work is supported by Core funding, TFBIS, MPI, KVH (Kiwifruit Vine Health), other CRIs (Plant & Food Research), and the Bioprotection Research Centre. More information: www.landcareresearch.co.nz/publications/innovation-stories

■ Declaring areas free of bovine TB

The number of TB-infected cattle and deer herds in New Zealand has dropped dramatically, from over 1700 in 1994 to just 66 by 30 June 2012. This reflects local elimination of TB from possums due to sustained and intensive regional-scale possum control to the point where TB is probably absent from large areas that previously contained infected possums – but can we be confident of this?

Over the last few years (in close collaboration with the Animal Health Board (AHB) and others), we have developed a quantitative framework for objectively assessing the probability that TB has been eradicated from a specific area. The framework combines predictions from a sophisticated model of TB in possums with multiple sources of surveillance data (including a radically new approach using traps and other possum-detection devices) to estimate the likelihood that TB is absent.

The framework, being used for the first time in 2012, is likely to enable AHB to declare tens of thousands of hectares are now free of TB. This is a crucial first step toward their goal of eradicating TB from 2.5 million hectares over the next decade or so. When local and regional eradication of TB is eventually achieved, the annual cost of TB management (currently \$84m per year) will be substantially reduced. Achieving the goal will also ensure that export industries worth \$20billion per year are permanently protected from the risk of TB-related threats to market access or product acceptability.

This work is supported by AHB and MBIE contestable funding. More information: www.landcareresearch.co.nz/publications/innovation-stories

■ Oral TB vaccination for wild possums

Eliminating bovine TB from wild possum populations is crucial if its control and eradication over entire landscapes is to be achieved in New Zealand. A long-lasting oral vaccination for possums could complement other TB control 'tools' in New Zealand, particularly where use of those other tools is heavily constrained. We have previously shown that oral vaccination with lipid encapsulated BCG can reduce TB infection rates in wild possums by over 90%. We have now completed the follow-on trial that showed residual protection can last for over two years following a single oral immunisation. This suggests that

operational use of a wildlife vaccine against TB is technically feasible. Not only would it be a valuable back-up tool in New Zealand, it would also assist other countries in their efforts to control TB in wildlife reservoirs of the disease.

This work is supported by AHB and MBIE contestable funding.

■ Humane traps

The development and testing of low-cost single-capture and novel multiple-capture traps ensure professional contractors and community groups have traps that meet welfare requirements and which are cost-effective for controlling possums, rats, and stoats. We worked with a small business (GoodNature) and DOC to help test the killing effectiveness (humaneness) of new self-resetting traps. In Animal Ethics Committee approved trials on ship rats and stoats, the automatic traps passed National Animal Welfare Advisory Committee (NAWAC) guidelines for both species.

We also developed an effective, very low cost, single-capture kill trap option (i.e. \$9 per traps vs \$160 for the GoodNature trap) especially for community groups that have limited operational budgets.

This work is supported by MBIE contestable funding.

■ More effective rabbit control

In partnership with Regional Services (Otago Regional Council), initial trials showed that the amount of toxic bait used for controlling rabbits could be reduced from 30 kg/ha to 10 kg/ha – with no reduction in efficacy – simply by shifting from broadcast sowing to strip sowing. Costs were reduced by 25% when strip sowing was used solely for the toxic application. In future trials using strip sowing for both prefeed and toxic bait, we expect costs will be reduced by as much as 50%. Further trials are planned this winter, including testing alternative options that could further reduce sowing rates and costs.

This research has the potential to significantly reduce rabbit control costs for farmers, some whom are currently spending up to \$100,000 annually. Reducing the amount of toxin being applied should help address some public concerns about 1080 use, and also reduce risks to non-target species.

This work is supported by MBIE contestable funding.



ENGAGING OUR STAKEHOLDERS

GOAL

Landcare Research's partnership with central and local government, industry and Māori organisations is valued by them as a way of improving the efficiency and effectiveness of science expenditure that leads to National Outcomes being achieved.

Context

Government is encouraging partnerships between government, industry and science so that science better informs management and policymaking by government and underpins innovation by industry. Increasingly, we are working directly with industry on solutions to specific issues and in identifying opportunities for sustainable economic growth.

Our most significant stakeholder partners in terms of science funding are DOC, MPI, MfE, AHB, and local and regional government. While we work with many businesses and industry sectors, strategic engagement is mostly through BusinessNZ and sector bodies such as ZESPRI, DairyNZ, FAR, and IrrigationNZ. Our science needs to be strongly aligned to the needs of these partners. Steering groups, technical advisory groups and regular meetings provide formal conduits for them to influence our science direction, priorities and delivery. As tangata whenua, Māori are important stakeholders – in

addition to our contribution to Vision Mātauranga (page 34), we participate in regular meetings, hui and capability-building initiatives with collaborating iwi.

Our National Outcomes, Impacts and science Portfolios have all been developed with considerable input from the relevant stakeholders who have helped develop the science priorities addressed by our Portfolios and who will co-invest in the science.

We are committed to making a significant step change in stakeholder and community access to the knowledge Landcare Research holds, especially in our databases and collections. We have a vested interest in knowledge stewardship – acquiring new data when and where they are needed, data-sharing synergies, data integrity, and their uptake and use by others. Two years ago, we proposed a national collaborative centre to facilitate access to land resource information across a number of agencies. The concept received a remarkable level of support from stakeholders, and in July 2012, we launched the National Land Resources Centre (see over page).

Highlights

Science Advisory Panel

We have appointed a 3-year Science Advisory Panel to support the Board and Senior Leadership Team through strategic science planning processes and allocating Core funds, evaluating and developing science excellence, and ensuring our research contributes to achieving our National Outcomes. The panel consists of six leading researchers (two from the UK, two from Australia, two from New Zealand) whose expertise covers the range of our research activities. The panel met for the first time in February 2012 and will meet subsequently at 6-monthly intervals.

Stakeholder Strategic Advisory Group

The Board commissioned a panel of seven stakeholders from business and industry, government and local government, asking them to focus on the major trends or issues that will drive change in New Zealand, and what they would expect the science sector, and Landcare Research in particular, to deliver in the next five years. Key messages from this panel were that we need to be bold in our mandate to lead; to focus on a smaller number of important relationships; invest in supporting quality conversations and understanding values; improve communication; and reframe the way science is shared including the form, timing and language of delivery. We have heeded these recommendations both in reorganising our numerous science programmes into 10 research Portfolios that are tightly focused on our National Outcomes and the needs of our key partners, and in developing the National Land Resource Centre.

National Land Resource Centre

New Zealand's economy is founded on its land resources. Agriculture, forestry, mining and tourism together provide more than 25% of New Zealand's GDP; hence our national prosperity is highly dependent on the 'land economy'. Stakeholders need fit-for-purpose, best-available information to guide the way we use the land to protect,

enhance and leverage this 'land economy'. However, the science of land resources is scattered across many providers so lacks coordination and strategy. The National Land Resource Centre (NLRC) is intended to remedy this.

The NLRC is an online and physical gateway to the land resource science projects, data, information and resources held by Landcare Research, other CRIs and agencies. The pan-organisational approach will help bring together information assets and focus on making science easier to understand and therefore of use for stakeholders in many different sectors, including those that have typically not engaged with the science community before.

The centre will also aid professional development in public and private sector organisations through initiatives such as practitioner training workshops, secondments, internships, and hosting visiting scientists. Similarly, with an ageing workforce in the soil and land sciences, the centre will look at ways of capturing the wisdom of retiring experts, stewarding data and information assets, and ensuring we have the ability to respond to future information needs.

NLRC was developed with Strategic Investment, and provides access to Core-funded databases. www.nlrc.org.nz

Wetland restoration – Waikato Raupatu River Trust

In working with the Waikato Raupatu River Trust (WRRT, Waikato-Tainui) on a number of wetland restoration projects, a 1-year Certificate of Technology course was developed in partnership with the Waikato Institute of Technology. Two inaugural 'Waikato-Tainui wetland scholarship' students completed the course in June 2012. Through fortnightly work placements and a 5-week summer internship with our researchers, the students learned practical field techniques and developed an understanding of wetland science. The highly-motivated students will use their new skills and knowledge to assist with future restoration projects in the Waikato-Tainui rohe. WRRT wishes to continue the very successful course until 2016.

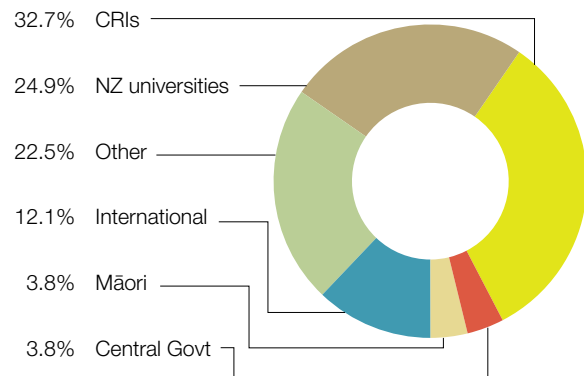
This work is supported by MBIE contestable funding and WRRT.

KPIs

The MBIE external Stakeholder Survey found that:

- 83% of respondents are satisfied with the way we set research priorities
- 97% of respondents have adopted knowledge or technology from Landcare Research in the past three years

Subcontracts to research partners
by sector (\$7.1 m)



'Other' includes business sector, NGOs and private individuals

Stakeholder relationships

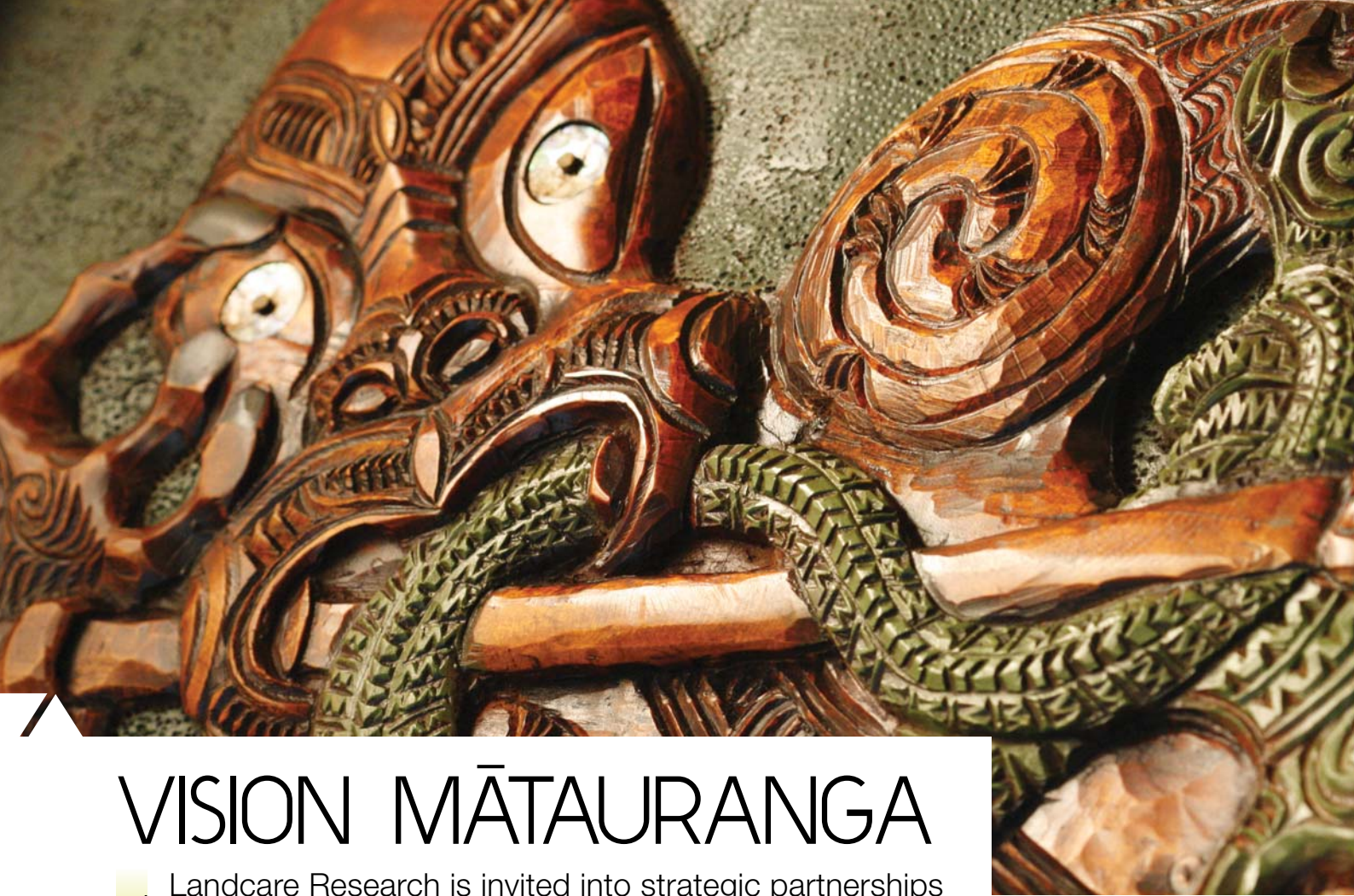
| For the year ended 30 June: | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|------|------|------|------|------------------|
| Technical expertise | | | | | |
| Staff invited to participate in stakeholder meetings or workshops | 191 | 251 | 193 | 281 | 259 ¹ |
| Landcare Research staff invited to join national advisory groups | 38 | 41 | 41 | 38 | 49 ² |
| Publications on technical information & research results | 165 | 181 | 349 | 374 | 371 |
| Science presentations to stakeholders & community groups | 279 | 205 | 220 | 271 | 259 |
| Partnership initiatives | | | | | |
| Memoranda of Understanding (MoU) | 16 | 12 | 16 | 10 | 6 |
| Client staff on Landcare Research advisory groups | 86 | 87 | 60 | 69 | 46 ³ |
| Reports on research results & issues | 200 | 177 | 185 | 223 | 284 ⁴ |
| Staff secondments – to other agencies | 3 | 4 | 3 | 3 | 5 |
| – from other agencies | 1 | 1 | 1 | 1 | 1 |
| Other agency staff co-located with us | 85 | 101 | 100 | 110 | 102 |
| Our staff co-located with others | 14 | 7 | 7 | 9 | 10 |

¹ Total includes 34 overseas, 98 NZ central and local government, 42 industry, 19 Māori, 19 NGO, and 47 with other NZ research groups.

² 61 staff invited onto 135 advisory groups including 43 overseas, 49 NZ government and local government, 3 industry, 2 Māori, 17 NGO, and 21 research groups with CRIs and universities. The total includes 17 new positions with central government agencies.

³ The External Advisory Group for Invasive Mammal Impacts, Beating Weeds and Small Mammal Pest Control did not meet in 2011/12. Scheduled meetings of the EAG were placed on hold while Landcare Research planned rationalisation of advisory groups in response to the shift to Core funding. Regular updates to external advisors (stakeholders) including DOC, regional councils, community groups, Ngā Whenua Rāhui, and the Animal Health Board have been provided via IMI programme meetings and the IMI newsletter. Also, a wide range of stakeholders have participated actively in planning for specific projects.

⁴ 144 contract reports and 140 other reports. In addition, 372 progress reports were produced.



VISION MĀTAURANGA

GOAL Landcare Research is invited into strategic partnerships with iwi and Māori organisations to address Māori needs, issues and aspirations.

Context

Māori are looking to science and innovation to enable them to meet their aspirations, realise business opportunities, and achieve sustainable management of natural assets.

Landcare Research is committed to increasing its integration of science and mātauranga Māori across all four of our National Outcomes. We have a number of projects with Māori to address specific cultural issues (e.g. cultural harvesting of native species, management of water and wetlands), visualising opportunities for development (see page 18), building capacity for responding to resource management issues, and exploring governance mechanisms that meet Māori aspirations for managing their land assets. These projects build on our 20-year history of working in partnership with various iwi.

We are committed to building the bicultural capability of our staff, including those visiting from overseas, and developing a strong bicultural ethos to ensure staff understand and appreciate the cultural context, dynamics, and environment when engaging and working with Māori communities. We provide Te Reo tuition, tikanga sessions and Treaty of Waitangi workshops at our larger sites.

KPI

- During the year, we engaged in 23 strategic partnerships in which we are linking science and mātauranga Māori in projects with iwi and Māori organisations and which address Māori goals and aspirations. Most of these are mature relationships built over many years through multiple projects and interactions.

Highlights

■ Te Urewera Stakeholder Summit

Te Urewera, in particular Te Urewera National Park, has held centre stage in the Tūhoe and Crown Treaty of Waitangi claim settlement negotiations for nearly four years. Aside from Te Mana Motuhake o Tūhoe (Tūhoe's desire for inherent powers of self-government), the iwi's aspirations include the return of Te Urewera National Park and restoration of their kaitiakitanga (guardianship) responsibilities. Key to this is an enduring governance system for Te Urewera National Park that embodies a Tūhoe worldview but which is interdependent with and meets the needs of all park stakeholders.

Te Kotahi ā Tūhoe commissioned Landcare Research to undertake independent interviews and facilitate a Summit enabling stakeholders to define principles and priorities for the governance and management of Te Urewera National Park. Broadly, there was positive support — stakeholders felt they shared common ground with Tūhoe in relation to how they value and use the park. Overall, personal use and well-being and the intrinsic properties of Te Urewera National Park were the most commonly mentioned values. Stakeholders felt that the greatest contribution they could make to management was through advice and counsel, closely aligned with labour and expertise for delivering services (e.g. track and hut maintenance) and infrastructure (e.g. provision of boating facilities) in the park. Common issues centred around the possibility of a Tūhoe Authority being unencumbered; the loss of free, open access to the park; and potential loss of opportunity to influence management decision-making. Representation, transparency and accountability were the three most commonly listed principles for governance.

This summit was funded by Te Kotahi ā Tūhoe

■ Customary harvest of seabirds

The results from our research into seabird populations support the Minister of Conservation's decision to reinstate customary harvest of kuia chicks (grey-faced petrel, northern muttonbird) by Ngāti Awa on Moutohorā (Whale Island), Bay of Plenty, and their lifting of a 50-year-old rāhui on harvesting chicks.

Te Tapatoru a Toi, a joint management committee consisting of representatives from Ngāti Awa, DOC and the general public, wanted more information about the status of the kuia population and safe harvest limits. Using field data in predictive habitat and population models, we estimated that there was a population of 84,000 breeding pairs of kuia on Moutohorā and that this population is growing at an average rate of 2% per year, which is consistent with a long-lived petrel species. Our population model predicted that the proposed level of annual harvest (200 chicks) by Ngāti Awa posed a negligible effect to the kuia population. Harvesting within these limits means the birds will continue to deliver both conservation (e.g. marine nutrient transfer) and cultural benefits (e.g. mātauranga revival and transfer) to the island and iwi.

This research was supported by MBIE contestable funding.

■ KEIA-R – decision framework

In collaboration with Māori organisations, under the umbrella of the Waahi-Whaanui Trust (Waikato-Tainui) and six marae that have strong genealogical connections to their ancestral river and lands, we developed a new framework to assist iwi/hapū groups and kaitiaki practitioners in organising and responding to growing workloads around resource management. Māori organisations increasingly have to address complex and interconnected cultural, social, environmental and economic issues, and to engage with many agency, industry and community groups.

Kaitiaki Environmental Impact and Assessment and Reporting (KEIA-R) is an issues-based framework that provides an easy way to capture and organise relevant information. It offers a step-by-step process guiding iwi/hapū and kaitiaki practitioners through day-to-day cultural–environmental management issues for their region or district. It identifies the appropriate tools, processes and methods to address particular needs (e.g. processing of resource consents, cultural impact assessments) and achieve desired goals, aspirations and outcomes.

This work was supported by Core funding.



SCIENCE COLLABORATION & EXCELLENCE

GOALS

- 1 Landcare Research-led teams are regarded as national ‘best teams’ that draw upon the complementary skills of CRIs, universities and other organisations, including those overseas, and deliver excellent science.
- 2 Landcare Research’s science excellence is enhanced, and opportunities are realised for the benefit of New Zealand, by managing and leveraging international connections.

Context

Collaboration between science providers is an absolute necessity because current and future environmental issues are becoming increasingly complex, requiring a broader range of science skills, facilities and resources than one institute (or even one country) can supply. Our well-established reputation for scientific excellence is integral to making connections with leading research teams and science agencies overseas, and to being part of global initiatives. International connectedness enables us to be at the forefront of scientific and technological developments that will help us fulfil our Core Purpose and deliver National Outcomes for New Zealand.

We support New Zealand’s multilateral/bilateral environmental commitments, trade agreements and export sector through our scientific expertise. Our partnerships with national science agencies in Chile and China are aligned with New Zealand Government initiatives in those countries. Similarly, we support New Zealand’s Official Development Assistance in Pacific Island Countries through capacity-building projects.

We are partners in a number of national and international collaborative research centres, networks and consortia – these are listed on page 41.

Highlights

■ SCImago Institution rankings

The SCImago SIR World Report 2011 covers 3042 research organisations worldwide and is the most comprehensive ranking of scientific output. The latest edition covers five years, from 2005 to 2009. We were ranked 3rd in New Zealand among CRIs and universities, with a normalised impact of 1.54, which means our publications have an average scientific impact 54% above the world average (=1).

In respect to the number of articles published in the top 25% SCImago ranked journals relevant to our research, we are in 7th place for New Zealand CRIs and universities. We are 4th with respect to international collaboration – 49.1% of our publications over the 5-year period had overseas co-authors.

'Excellence Rate' is a measure of high quality output – we have moved to 1st place in the Oceania rankings, with 20.9% of our publications included in 10% of the most cited papers within our scientific field.

■ Intergovernmental Panel on Biodiversity & Ecosystem Services

In collaboration with DOC, we organised a workshop and meetings on GEO BON (Group on Earth Observations – Biodiversity Observation Network) and its application to IPBES (Intergovernmental Panel on Biodiversity and Ecosystem Services). GEO BON participants are coordinating a global network that gathers and shares information on biodiversity, provides tools for data integration and analysis, and contributes to improved environmental management. More than 90 governments have agreed to establish IPBES as the leading global body providing scientifically sound and relevant information to support more informed decisions on how biodiversity and ecosystem services are conserved and used around the world. The workshop was attended by Landcare Research, NIWA, Scion, Lincoln University and the University of Lisbon based GEO BON coordinator of the Terrestrial Species Working Group. The coordinator was very impressed

with New Zealand's efforts, particularly those of DOC and Landcare Research, in leading the measurement of biodiversity status and trend, and for our expertise in biodiversity informatics.

■ Biodiversity partnerships with Chile

In February, we signed a Memorandum of Understanding with the Instituto de Ecología y Biodiversidad (IEB), a consortium of biodiversity expertise across six Chilean universities that is funded by the Chilean Government science and technology agency CONICYT. This will facilitate cooperative biodiversity research. The temperate regions of Chile are very similar climatically and geographically to New Zealand. The shared Gondwanan origin of both land masses means that we have some strikingly similar biota (e.g. southern beeches (*Nothofagus*) dominate cool-temperate rainforests in both countries). The two countries also face similar problems of biological invasions (e.g. invasive gorse and broom), and some Chilean plant species are invading New Zealand. The two countries also face similar land-use-intensification pressure on native biodiversity. Following signing of the MoU, a group of our ecologists worked with their Chilean counterparts on a synthesis of plant invasions common to both countries, and to develop protocols for shared work.

Our visit to Chile was supported by CONICYT. www.conicyt.cl

■ Partnerships with Chile in greenhouse gas modelling

In another CONICYT-supported project, we are working with the National Institute of Agriculture (INIA Rumehue) and Universidad de la Frontera to help strengthen Chilean capacity in greenhouse gas research, particularly in relation to agricultural systems. We were invited 'International Experts' at the FAO and FONTAGRO International Workshops on 'Limitations and challenges for the improvement of the livestock sector greenhouse gas inventories' and 'Defining protocols for the determination of nitrous oxide emissions' organised for South and Central American countries; and at several other conferences for Chilean researchers and policy staff. This work has provided a regional fertiliser-emission-factor value that is

almost 1/10th of the current default IPCC value used in the Chilean greenhouse gas inventory. In addition this could be reduced by 50% by adding nitrogen inhibitors.

■ Collaboration with China

We have completed a 2-year joint project with the Xinjiang Institute of Ecology and Geography in Urumqi and the Partner Institute for Computational Biology in Shanghai. The project was on the impacts of climate and land-use change on grazed ecosystems. It had three components: (1) review the global problem of grazing impacts and climate change in predominantly natural ecosystems; (2) review how seasonality, palatability and selection by grazing animals modulate plant communities ; and (3) quantify ecosystem carbon balance, using existing measurements at the Fukang Station of Desert Ecology in Xinjiang and models developed by Landcare Research. The project was funded under the China–New Zealand Strategic Research Alliance.

Under the NZ–China Environmental Cooperation Agreement, MfE and its Chinese equivalent (the Ministry for Environmental Protection) have facilitated exchanges between Landcare Research and the Chinese Research Academy of Environmental Sciences to build research collaborations on invasive species, biodiversity and climate change. We have agreed on four priority areas for collaboration: (1) systematic conservation planning; (2) risk assessment for invasive species; (3) systems approaches to managing environmental change; and (4) soil carbon.

Some of this work was supported by MBIE International Relationships Funding.

■ New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC)

The role of NZAGRC is to develop technologies for New Zealand to meet its international greenhouse gas emission obligations without reducing agricultural output. The centre comprises nine organisations, funds national collaborative research, and promotes international engagement through the Global Research Alliance. We are leading research to maintain and enhance soil carbon storage and reduce nitrous oxide emissions in grazed grassland systems, particularly dairy farming. The science is challenging but is progressing well because of the collaborative, best-teams approach.

We are combining long-term measurements at field sites with increasingly sophisticated computer models to

investigate processes that (1) regulate denitrification (to reduce nitrous oxide emissions) and (2) soil carbon inputs and losses. For the former, we are developing and testing molecular and gaseous measurement methods to identify pathways to nitrous oxide production to manipulate the biological processes and accelerate complete denitrification and reduce nitrous oxide emissions. For the latter experimental manipulations, we are coordinating research undertaken by the University of Waikato, AgResearch and Massey University using swards of mixed grass species (instead of the more conventional ryegrass), introducing exotic worms, and applying biochar in experiments to test the effectiveness of increasing carbon inputs, incorporating and retaining carbon at depth in soil.

This multi-agency work will lead to practical methodologies that can be adopted by farmers to reduce greenhouse gas emissions.

■ The DNDC Global Network

Our long-standing collaboration with the University of New Hampshire based developer of the DNDC model has facilitated our development of the New Zealand specific version (NZ-DNDC). Our NZ-DNDC model is used overseas to estimate nitrous oxide emissions from grazed grasslands, and now we host the Global DNDC Network (~90 active subscribers) that facilitates ongoing collaboration.

Our expertise with the DNDC model led to our involvement with NZAGRC to help develop a nitrous oxide emission module for incorporation in a farm systems model. During 2011/12, we hosted researchers from Chile, Japan and UK, all of whom wish to collaborate on DNDC modelling for application to their country-specific agricultural management systems. Recently we have also been approached by the Chinese Academy of Agricultural Sciences, University of Sao Paulo Brazil and INIA (Chile), to visit and develop collaboration on greenhouse gas modelling projects.

■ Veg-X

Veg-X is the draft international exchange standard for plot-based vegetation data, the development of which has been led by Landcare Research. These standards will enable plot data over extensive spatial and temporal gradients to be integrated and analysed in order to model vegetation change and dynamics at local and global scales.

This year, there has been a major international effort to implement Veg-X. The Botanical Information and Ecology Network (BIEN) is a network of researchers interested in global patterns of plant diversity, function and distribution. The central goal is to understand the determinants of the past and present plant distributions and abundance. This knowledge is essential for predicting how species, vegetation and agricultural crops will respond to future climate changes. The BIEN team is working to assemble a demonstration project that includes most of the premier plant biodiversity databases for the Americas. By the end of 2012, they will have produced a single resource giving species names, locations, and often abundances, for about 25 million species' occurrence records.

BIEN has been using Veg-X to facilitate the mapping of plot data to a common schema as they move closer to the ultimate goal of uniting an ever-growing pool of plant distributional data with information on plant co-occurrence, ecology, traits and phylogeny.

Our contribution uses Core-funded research.

■ Knowledge-Based Bio-Economy (KBBE)

As part of suite of collaborations under the European Commission's Knowledge-Based Bio-economy (KBBE) initiative Landcare Research is leading discussions on potential collaborative opportunities with Australia, Canada and the European Union around sustainable agriculture and water use. The collaborative initiative will initially involve a stocktake of the technologies being developed in each country, the methods used to facilitate their uptake within agricultural practice, and the areas ripe for further collaboration. As part of the project, New Zealand is also supporting a researcher to travel to one of the partner countries to attend a conference and visit relevant institutes.

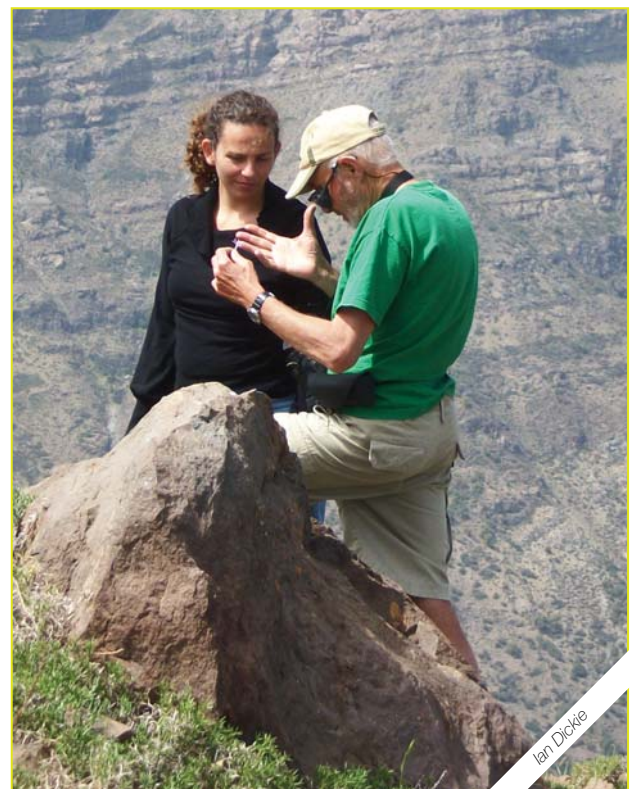
■ Supporting New Zealand's Official Development Programme

This year, we provided technical assistance to the Governments of Fiji, Ecuador and Korea, and to national park managers in Ethiopia, relating to the development of national carbon accounting systems that comply with UNFCCC guidelines for gaining credit for carbon sequestration under the Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) framework.

Under contract to Biosecurity NZ (now part of MPI), we continued work on developing an online pest identification system (PaDIL) for quarantine services in five Pacific Island countries. We supported a number of capacity-building initiatives with Pacific regional organisations University of South Pacific and IUCN, including cost-benefit analyses to prioritise pest control across Pacific Island Countries.

With MFAT, we completed our pilot programme to develop sustainable livelihoods for poor inhabitants of two river catchments in Ecuador's Cotopaxi Province. Outcomes include hydrological monitoring for more equitable water management, biocontrol of pests and diseases, and projects to provide alternative sources of income (e.g. alpaca production, organic vegetables, and medicinal plant production).

We assisted SPREP with assessing the feasibility of 'integrated financing strategies' to help meet Fiji and Samoa's obligations under the United Nations Convention to Combat Desertification. The global agreement encourages participation of local people in combating land degradation in arid and dry lands across the world, and in fighting poverty through improved soil productivity.



Aurora Gaxiola and Peter Williams in the Andes discussing weeds

KPIs

Collaboration

- MBIE's external Stakeholder Survey showed 91% of respondents for Landcare Research have confidence that we have the ability to put together the most appropriate research teams
- This year we subcontracted \$7.1m of research to collaborating agencies, including universities, CRIs, and Māori agencies (see page 33)
- We undertook 109 collaborative research agreements, including 44 with central and local government, 5 with industry, 17 with Māori and 44 with overseas partners. We had another 194 collaborative agreements with other New Zealand research providers
- We signed 1 new licensing agreement with a New Zealand company, and 4 joint venture agreements with New Zealand research partners (we signed no new licensing agreements, patents or joint venture agreements with international partners)

Science excellence¹

- 15 staff were recognised by colleagues with awards (7 international), including having a species named after them and winning Marsden Grants; another 3 staff were awarded travel grants to attend overseas conferences (see page 57 for the top awards)
- 39 staff hold 82 positions on the editorial boards of scientific journals; 67 of these are international and include the mega journal Zootaxa, founded by one of our staff

- 39 staff hold 56 positions in professional societies (including 10 Fellows); 19 of these are international
- 63 staff hold 143 positions on advisory boards, technical groups and review panels; 45 of these are international
- 12 staff hold 17 directorships or board memberships; 3 of these are international
- 8 staff were invited to give keynote or plenary addresses at significant national and international conferences, with costs fully or partly covered
- Our staff published 241 peer-reviewed papers in scientific journals during the year

¹ Data includes our Research Associates but excludes staff in any collaborating or sub-contracted organisation.

International revenue

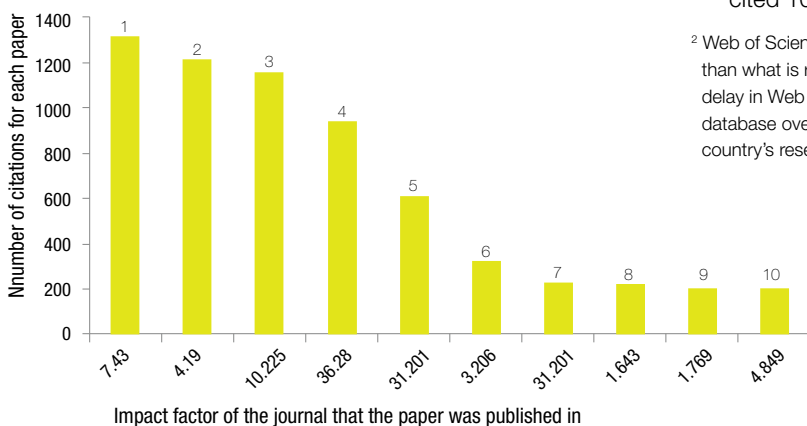
- See Revenue by source (page 59)

Web of Science metrics at 1st July 2012²

- 30% of our peer-reviewed scientific papers recorded by Web of Science were published in the top 25 journals relevant to the scope of our research
- Of 174 joint peer-reviewed scientific papers, 105 (60%) were co-authored with overseas colleagues and another 23% were co-authored with colleagues in another New Zealand organisation or university
- Over an 18 month period, papers were co-authored with colleagues from 54 different countries
The countries we most commonly collaborated with are USA, Australia, England, Germany, Canada, Spain, Sweden, People's Republic of China, France and Switzerland
- Over a rolling 8-year period, our published papers were cited 10.8 times on average

² Web of Science has fewer publications for Landcare Research in 2011/12 than what is recorded by our own library. There may be up to a 6 month delay in Web of Science adding publications to their records, and the database overlooks some New Zealand journals that are important to this country's researchers and research stakeholders.

The 10 most cited papers 2002-12



The number of times a paper is cited is a measure of its influence. More than 80% of scientific papers in the world are cited less than 10 times; at least 40% are never cited at all despite being read by colleagues.

The graph (left) shows the influence that the top papers published by our staff in the last 10 years.

Formal collaborative initiatives

We are part of several national and international research centres, consortia and networks in areas relevant to our National Outcomes and capability as outlined in the Scope of our Core Purpose (see page 2).

Outcome 1: Biodiversity

- The Centre for Biodiversity and Biosecurity (CBB) with the University of Auckland, including the Joint Graduate School www.cbb.org.nz/
- The Regional Councils' Biodiversity Forum that prioritises their biodiversity research needs
- The Invasive Animals Cooperative Research Centre (CRC), Australia's largest integrated invasive animal research programme www.invasiveanimals.com/
- The new Southern Temperate Ecosystems Research Network (STERN) with the Institute of Ecology and Biodiversity in Chile, the initial focus of which is invasive species
- The Global Biodiversity Information Facility (GBIF) that is collating records from biological collections around the world, and Species2000 Catalogue of Life that is creating a valid checklist of the world's species www.gbif.org/ www.sp2000.org/

Outcome 2: Land resources

- The KiwiImage consortium, a multi-agency programme to acquire and use new higher resolution, multi-purpose satellite imagery for all of New Zealand and its sub Antarctic islands
- The Sustainable Land Use Research Initiative (SLURI) pools soil science expertise across three CRIs to develop new tools for regulators and land managers
- The Sustainable Land Use Alliance (SLUA) between four CRIs supports a more collaborative and integrated approach to research and capability development www.sluri.org.nz
- The National Land Resource Centre (NLRC) provides a gateway to soil and land data, and will have

responsibility for coordinating capability development across SLUA www.nlrc.org.nz

- The Global Soil Map is a worldwide consortium to make a high resolution digital soil map to help manage issues like food production and hunger eradication, climate change, and environmental degradation. We are the Scientific Coordinator of the Oceania Node and lead the Cyber-informatics working group www.globalsoilmap.net
- The new New Zealand Antarctic Research Institute, an initiative led by Antarctic New Zealand to leverage overseas and philanthropic funding

Outcome 3: Greenhouse gases

- The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) is a partnership of five CRIs, Massey and Lincoln universities, DairyNZ and the Pastoral Greenhouse Gas Research Consortium (PGgRC) www.nzagrc.org.nz/
- The New Zealand Climate Change Centre (NZCCC) with Victoria University of Wellington, University of Canterbury, Massey University, and many of the CRIs www.nzclimatechangecentre.org/
- The Global Research Alliance on agricultural greenhouse gases involves more than 30 countries www.globalresearchalliance.org/

Outcome 4: Industries and business

- The New Zealand Life Cycle Management Centre (NZLCMC) with Massey University and three other CRIs <http://lcm.org.nz>
- The New Zealand Centre for Sustainable Cities with University of Otago and five other partners <http://sustainablecities.org.nz>
- The New Zealand Sustainable Business Council, which provides business leadership as a catalyst for change towards sustainable development www.sbc.org.nz

Links with Universities

All our larger sites are on or close to university campuses, and we have a number of joint appointments with New Zealand universities. This facilitates collaborative research, and makes it easier for our staff to supervise postgraduate students and present invited lectures. During the year, we hosted 20 postdoctoral researchers – talented young researchers embarking on science careers.



Sam Carrick with Lincoln University soil science students

New agreement with Lincoln University

Landcare Research and Lincoln University formalised a collaboration agreement in March 2012, and made two new strategic appointments: (1) the University's Director of the Agri-business and Economics Research Unit has been contracted (part-time) to lead our Supporting Trade Portfolio; and (2) one of our researchers has been appointed to a joint lecturer position in the Soil and Physical Sciences Department at the university. This latter appointment recognises the merits of a joint 3-year field-based project in which final-year students have been creating a detailed soil map of a cropping farm (near Ashburton). The map is not a mere academic exercise – it is used by the farmer, researchers, and industry to improve both irrigation- and nutrient-use efficiency. (A multi-agency Sustainable Farming Fund project into variable rate irrigation, led by Landcare Research, is located on the farm.) The students have benefited immensely from the experience.

Collaborative research centres, networks & consortia

We are partners in a number of collaborative research centres, networks and consortia (e.g. NeSI) that include universities – these are detailed on the previous page.

Links with universities

| For year ended 30 June: | 2008 | 2009 | 2010 | 2011 | 2012 |
|--|------|------|------|------|------------------|
| NZ university staff in our research projects | 54 | 51 | 48 | 38 | 41 ¹ |
| Our staff in university projects | 12 | 25 | 18 | 13 | 13 ² |
| Postgraduates being supervised by our staff | 94 | 98 | 98 | 71 | 102 ³ |
| Staff paid to lecture in university courses | 9 | 12 | 14 | 12 | 7 ⁴ |
| University positions held by staff | 44 | 38 | 41 | 36 | 39 ⁵ |

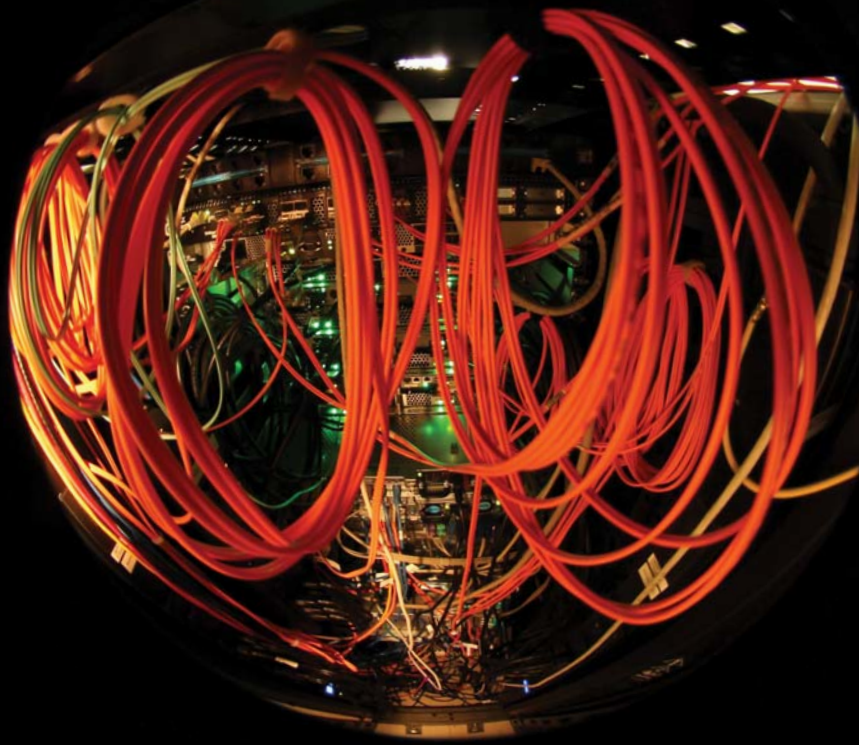
¹ 41 staff and postgrad students from 7 universities collaborating in 26 of our research projects

² 13 of our staff in 17 programmes at 7 universities

³ 69 PhD, 32 MSc and 1 postgraduate diploma; does not include students supervised by overseas research associates

⁴ 7 staff delivered 9 sets of paid lectures; another 29 staff provided 44 sets of guest lectures

⁵ 29 staff hold 39 honorary positions (professorships, lectureships, fellowships) in New Zealand and overseas universities



INFORMATICS & SYSTEMATICS

GOAL Landcare Research's science knowledge, databases and collections, analyses and modelling are readily available and can be used efficiently and effectively, both internally and externally.

Context

Landcare Research is custodian of and curates seven Nationally Significant Databases and Collections – the largest holding for any of the CRIs, and larger than equivalent collections held by museums in New Zealand. The collections and databases cover biological resources (species and ecosystems), soil and land resources, and cultural knowledge. They are used extensively in taxonomic and systematics research and to underpin New Zealand's biosecurity, biodiversity, export/import trade, and land management, including primary production, conservation and environmental management (i.e. the delivery of our National Outcomes).

Our informatics research is focused on designing information systems that can manage and process complex data and ideas in order to deliver the right

knowledge, to the right person, in the right place, time, and form. Informatics can create new value and opportunities by integrating and interpreting data across multiple sources and agencies.

Where appropriate, information from our systematics and land resource Nationally Significant Databases is available online under an open-licensing agreement. Data can be freely used for public good (non-commercial) purposes provided we are acknowledged as the source of data.

We develop new software applications to enhance knowledge transfer and to increase the accessibility and interoperability, nationally and internationally, of data in these databases.

Highlights

National e-Science Infrastructure

We are a partner in the \$48m National e-Science Infrastructure (NeSI) investment by the Government, NIWA and the Universities of Auckland, Canterbury and Otago to build and operate three complementary high-performance-computing facilities. The first stage of Landcare Research and University of Auckland's joint facility went live in early February 2012.

The first Landcare Research project to take advantage of NeSI was one examining genomes of native stick insects. Genomic data are key to understanding the evolution of species and how closely related they are to other species, which in turn affects taxonomic and conservation strategies. Increasingly-sophisticated DNA sequencing technologies are generating vast amounts of data, which presents technical challenges for data management, processing and analysis.

Previously it took a whole week to process DNA sequence data from each individual stick insect, even when using a fast multi-core desktop Linux machine with plenty of RAM. However, using NeSI resources, processing time was reduced to a mere three hours; a somewhat dramatic and significant improvement! Further improvements are expected as we explore the options of processing multiple files simultaneously and by chaining multi-step sequence analyses together in an automated process.

NeSI is a Strategic Investment project.

Tuakiri - Access Federation

We worked with the Universities of Auckland and Canterbury to develop Tuakiri - New Zealand Access Federation, a new service for member universities and CRIs. Tuakiri (meaning 'identity' in Māori) provides a framework for simplifying controlled access to NeSI, research data and developmental workspaces, and

resources located in other organisations. The key benefit is that users only need one login – the personal login for their own organisation – to reach multiple service providers. Tuakiri automatically checks with the 'home' organisation to verify that the user is legitimate and determine what level of access that person has. For example, university students would generally have access to limited information resources; whereas researchers collaborating on new commercially-sensitive technologies or requiring NeSI resources for computationally-intense investigations would have much deeper access to shared resources.

Tuakiri marks a very positive step towards supporting an increasingly collaborative approach to research and education in New Zealand. It brings New Zealand into line with other similar restricted-access federation services available for education and research institutions in Australia, the US, UK and Europe.

Development of Tuakiri was sponsored by MSI. It was launched in July 2012 and is now self-supporting with members paying an annual fee. One of our staff is Vice-President of the Tuakiri Executive.

Data management

Data management is a common challenge for scientific organisations the world over. Our effectiveness in delivering environmental solutions depends upon our ability to access, process and store data and make information available in user-friendly fit-for-purpose ways. Our Data Management and Warehousing project supports our contractual data obligations for our major databases as well as the myriad smaller everyday datasets that support our research. It also ensures our data management and data standards are consistent with evolving global standards (and hence that our datasets can be integrated with overseas datasets) and will enable many of Landcare Research's environmental-modelling research efforts to move to the new NeSI high-performance-computing facilities.

This is a strategic investment project.

KPIs

In July/August 2012, we conducted an on-line survey of people using our Nationally Significant Databases and Collections; 291 people chose to respond:

- 92% said they were either completely or very satisfied with the databases and collections services we provide
- 88% said they were either completely or very satisfied

with the methods for accessing the resources

- 78% said the resources were essential or very important to their work
- 95% said the resources were essential or very important to New Zealand and internationally

| Land Resource Information Systems (LRIS) (full year data below but, as LRIS was launched in 2010/11, no full-year comparative data is available) – provides access to the Land Resource Inventory (NZLRI), the national Soils Database (NSD), S-map, Digital Elevation Models and more. http://iris.scinfo.org.nz | |
|---|---------|
| Application loads* | 2976 |
| Page views | 128,956 |
| Visits | 12,816 |
| Total users | 3596 |
| S-map Online (11 months data) – the new national soils database that provides access to digital soil information, including maps and fact sheets. http://smap.landcareresearch.co.nz | |
| Application loads* | 9254 |
| Point queries | 13,391 |
| Visits | 11,061 |
| Our Environment (7 months data) – provides access to a wide range of environmental data. http://ourenvironment.scinfo.org.nz | |
| Application loads* | 2633 |
| Page views | 12,797 |
| Visits | 4487 |

* Each Application load equates to clicking the button on the homepage to start the mapping software

| National Vegetation Survey Databank (NVS) – includes plot records, maps & photos spanning 50 years http://nvs.landcareresearch.co.nz | 2011 | 2012 | % change from 2011 |
|---|------|-------|--------------------|
| Datasets provided on request | 1243 | 1195* | - 4% |

* Excludes datasets available through NVS Express on-line.

| Specimens loaned or gifted from Nationally Significant Biological Collections | 2011 | 2012 | % change from 2011 |
|---|------|------|--------------------|
| NZ Arthropod Collection (NZAC), including nematodes - specimens | 7500 | 4785 | - 36% |
| International Collection of Micro-Organisms from Plants (ICMP) - cultures | 884 | 598 | - 32% |
| NZ Fungal Herbarium (PDD) - specimens | 452 | 263 | - 43% |
| Allan Herbarium (CHR) - specimens | 1087 | 4063 | + 273% |
| NZ flax & living plant collections | 38 | 25 | - 34% |

Specimen data are available online through our systematics databases (<http://bcd.landcareresearch.co.nz/>), the NZ Virtual Herbarium (www.virtualherbarium.org.nz), the NZ Organisms Register (www.nzor.org.nz), and the Global Biodiversity Information Facility (www.GBIF.org).



KNOWLEDGE & TECHNOLOGY TRANSFER

GOAL Landcare Research adds value to the New Zealand economy through commercially viable products and services, their transfer to partners in the private sector and, where appropriate, overseas licensing.

Context

Government, local government, business and industry are increasingly expecting new technologies and credible, evidence-based, defensible solutions to a range of environmental, land and water, and biodiversity management issues. In addition to contracted research and consultancy services for clients, we also deliver a range of commercial services that are closely aligned to our Core Purpose. We typically operate in emerging rather than the established markets addressed by the sector-based environmental consultants.

We continue to seek ways to speed the availability of new knowledge and technology to potential markets. In refining prototype technologies, we take a partnership approach with early adopters. In June 2012 Landcare Research joined the Kiwi Innovation Network (KiwiNet), which is a consortium of CRIs and universities dedicated to taking a collaborative approach to commercialisation.

Landcare Research undertakes a wide range of knowledge transfer initiatives that are focused on the timely sharing of relevant information in accordance with end-user priorities. Such initiatives include the new National Land Resource Centre and new web portals (e.g. <http://Iris.scinfo.org.nz/>), applications and frameworks to increase access to and usability of data in our Nationally Significant Databases and Collections.

This year, we developed a highly-successful lunchtime seminar series for policymakers, government science teams and environmental stakeholders in Wellington. Each month, one of our senior researchers presents science relevant to a topical policy issue. DOC, MPI, TPK and MfE have all hosted at least one seminar each. The series has prompted much ongoing discussion within and between the various agencies.

Highlights

EcoGene®

EcoGene® provides DNA diagnostic services for conservation, biosecurity, food safety, illegal trade and Resource Management Act applications for New Zealand and overseas organisations. Over the past four years, EcoGene has significantly expanded its client base from conservation and biosecurity agencies (DOC and MPI) to include industry (e.g. ZESPRI, Fonterra, Solid Energy).

New services available this year include genotyping of pāteke (the endangered indigenous brown teal) to assist DOC's recovery programme; and testing for resistance to existing rodenticides in rats. A new ultra-sensitive test detects whether pig DNA is present or not in food. This service is of value to New Zealand food exporters wanting to verify or disprove less-reliable overseas tests indicating product contamination.

Screening for chytrid fungus, a pathogen responsible for the decline of frogs globally, continues to be a significant revenue source for EcoGene with clients in New Zealand and Australia. Our test capability in this area was upgraded this year enabling us to more effectively service the increasing number of Australian clients.

EcoGene contributes to Outcomes 1 and 4.

Enviro-Mark®

This year, we launched a new website and developed a fresh bold look for the Enviro-Mark® programme. These have been very well received by the 180 member companies, who have been quick to use the new certification marks on product labels, packaging and marketing materials. The new website features a 'members only' area that provides ready access to programme checklists, guidance notes and resource materials.

OfficeMax has the largest multi-site membership, with Mighty River Power (Generation) the next biggest. The Toyota New Zealand dealer network, which has 32 dealerships across 66 sites, continued to make excellent

progress during 2011/12 with all dealerships achieving Bronze and Silver certification, and many are now working towards achieving Gold.

During the year, we ran six 'Introduction to Internal Auditing' workshops; three 'Get the Green Advantage' (member only) seminars; and 20 workshops covering all five levels of the programme. The quarterly e-newsletter has a circulation of about 1300.

Enviro-Mark contributes to Outcome 4.

EBEX21®

Our Emissions-Biodiversity Exchange (EBEX21) programme sold 8450 AAUs (assigned amount units of carbon) on behalf of landowners during 2011/12. The majority of these units were purchased by carboNZero^{Cert}™ customers. We have been working with two landowners to implement the Field Measurement Approach (FMA), which is a mandatory on-site measurement of carbon stocks using MPI-specified field methodology.

EBEX contributes to Outcomes 1 and 4.

Precision irrigation technology

Sensor mapping provides high resolution (<10 m) quantification of paddock-scale soil variability, which enables soil management zones to be assigned for varying irrigation scheduling under one irrigation system. With support from MPI and in partnership with industry, Massey University's Centre for Precision Agriculture, Foundation for Arable Research and DairyNZ, we are developing and refining variable rate irrigation (VRI) technologies.

One of our partners, Precision Irrigation – Lindsay Corporation, has modified sprinkler systems so that individual sprinklers can be programmed to switch on and off, thus enabling VRI to be matched to the soil management zones.

Our prototype web-enabled wireless soil moisture sensor networks (WSNs) continuously monitor soil moisture

within each zone under the irrigator. The WSNs use mesh networking technology to transmit data along the most efficient pathway between nodes to a base station. If one node fails, the other nodes simply re-route along any other available pathway. The soil moisture data can be accessed remotely and used to assist variable placement and timing of irrigation to soil management zones. The ultimate goal is complete automation of the VRI system using real-time soil moisture monitoring of soil zones.

Three 2-year-long trials (supported by HydroServices, Streets Instruments and Waterforce) achieved up to 36% water savings with no negative impact on yield and a current return on investment for the farmers estimated to be between 1 and 5 years. Water saved at the Fairlie dairy farm was diverted to otherwise unirrigated parts of the farm to increase pasture production. This enabled the cost of converting three systems to VRI to be paid back within one year. On the Manawatu Sand Country arable farm, a 36% water saving resulted from large areas under the pivot requiring no irrigation at all because of well-distributed rainfall over the season. The VRI system on an Ashburton arable farm, where soils vary from very stony to silt loams under one irrigator, achieved 20% water saving in both years. These trials highlight what can be achieved by partnering new ideas with industry.

This work contributes to Outcome 2.

■ Pest control products

Two new products were licensed to Connovation: (1) a new type of stoat bait, which is now being scaled-up to commercial production for use with their existing toxins; and (2) chewcards, which are a low-cost means of detecting vertebrate pests. When filled with peanut butter, the cards appeal to many species, each of which leaves distinctive chew marks. The cards are highly cost effective for identifying which pests are present and for indexing population numbers before and after control operations. They are used by AHB, conservation groups, Landcare Trust, DOC and regional councils.

These technologies contribute to Outcomes 1 and 4.

■ Sirtrack

In November 2011, Landcare Research sold its Havelock North-based wildlife tracking subsidiary Sirtrack to Lotek Wireless Inc. All staff transferred to the new owner. Lotek is a long-established, innovative business committed to growing its market share. The two companies have complementary technologies, which is exciting for Sirtrack's future product development and market presence. Land and buildings were purchased by a New Zealand investor.

■ The carboNZero programme

The carboNZero^{Cert™} programme, established by Landcare Research in 2001, provides organisations with an internationally-recognised certification process (CEMARS[®]) for measuring and managing their carbon (greenhouse gas) footprints. The programme also provides a carboNZero certification option for offsetting the emissions that cannot be reduced. In New Zealand, 138 organisations use these services and hence the programme contributes significantly to the achievement of our fourth National Outcome.

Membership by Ricoh in New Zealand has led to their Australian operations also joining. Through our partner Achilles in the UK, carboNZero's CEMARS certification scheme has clients that include the Environment Agency, the Scottish Parliament, Volvo and a number of major utilities. Membership is also increasing in Chile and Australia.

The carboNZero programme became a wholly owned subsidiary, carboNZero Holdings, on 1st July 2011. The 2011/12 year has been a challenging one with significant investment in overseas growth not matched by growth in membership. This reflects the tough financial conditions experienced by many businesses. Changes have been made to the programme strategy, which now highlights the need for an investment partner that brings experience of global certification and carbon markets. Finding such an investor is a target for 2012/13.

The carboNZero programme contributes to Outcomes 3 and 4.

KPIs

- MBIE's external Stakeholder Survey found that 97% of respondents for Landcare Research had adopted knowledge or technology from Landcare Research in the past three years

| For the year ended 30 June: | 2008 | 2009 | 2010 | 2011 | 2012 |
|--|------|------|------|------|------------------|
| Knowledge transfer | | | | | |
| New or improved products, processes & services | 81 | 73 | 70 | 80 | 73 |
| Reports on research results & issues | 200 | 177 | 185 | 223 | 284 ¹ |
| Publications on technical information & research results | 165 | 181 | 349 | 374 | 371 |
| Science presentations to stakeholders & community groups | 279 | 205 | 220 | 271 | 259 |
| Conference presentations to scientific peers | 192 | 232 | 169 | 287 | 279 |
| Mentoring businesses | | | | | |
| Enviro-Mark workshops | NA | NA | 22 | 24 | 29 |
| Technology transfer | | | | | |
| Patents granted | 0 | 1 | 1 | 1 | 0 ² |
| Licensing arrangements | 2 | 3 | 2 | 2 | 1 |
| Joint ventures | 0 | 0 | 1 | 1 | 4 ³ |
| Spin-off companies formed | 0 | 0 | 0 | 0 | 1 ⁴ |

¹ Includes 144 contract reports and 140 other reports. In addition, we provided a further 372 progress reports.

² No patents were acquired during the year but three provisional or complete patent applications are expected to have patents granted by 30 June 2013.

³ In addition to licensing arrangements and Joint Ventures, partnering agreements include 6 MoU signed during the year plus other initiatives covered on page 33.

⁴ carboNZero Holdings commenced operating as our fully-owned subsidiary company on 1 July 2012. (Sirtrack was sold during 2011/12)

- We produced 12 different newsletter series (print or e-newsletters), which are available through our website as well as being sent directly to partners and stakeholders. Each specifically focuses on the needs of particular client, stakeholder and end user groups. These newsletters are received very positively.
- We produce short informative video clips about our science, products and topical issues. These 76 videos are available through our YouTube channel www.youtube.com/landcareresearch, which is organised according to 15 playlists or themes. In addition, we contribute to scientific knowledge transfer videos produced by AHB and DOC.
- We organised several knowledge transfer training workshops for end user practitioners in the wider community. The most significant of these workshops were training in biocontrol of weeds techniques and identifications, pest management ('Biosecurity Bonanza'), how to design and build raingardens to retain stormwater runoff, and organising the annual Sanctuaries of New Zealand conference and workshop.
- We organised the 2-day BioBlitz 2012 in the Auckland Botanic Gardens, Manurewa. The collaborative BioBlitz events are major knowledge sharing exercises to engage the local community in biodiversity and systematics science, and to foster greater appreciation of biodiversity in urban environments. This year, BioBlitz was part of the 1-day South Auckland Schools' Programme organised by the Manukau Beautification Charitable Trust and the Auckland Botanic Gardens.



OUR ORGANISATION

People are the lifeblood of any organisation engaged in the pursuit of knowledge and innovative research. We strive to support our staff in this, and to provide a stimulating working environment that encourages world-class science and meets our wider social and ethical responsibilities. Our investments in infrastructure ensure staff have excellent facilities and that important assets (such as our biological collections) are better protected.

We have a culture of collaboration to enhance our performance. Collaboration is a characteristic of our research, and it also applies to achieving operational efficiencies and performance. We are part of several pan-CRI initiatives to improve workforce planning, and All-of-Government initiatives to broker excellent service and supply contracts, greater IT benefits, and more sustainable options for both procurement and waste management.

Landcare Research has a decade-long reputation for corporate sustainability performance and transparent public reporting. We publish detailed accounts of our performance on our website:
www.landcareresearch.co.nz/about/sustainability

■ Certifications and partnerships

We have:

- ISO 14001 certification for our environmental management system and practices
- Tertiary accreditation (the highest level) in the Accident Compensation Commission (ACC)'s programme for Workplace Safety Management Practices
- carboNZero^{Cert™} certification across all our sites
- Our online reporting meets application level A of the GRI Framework (self-assessed)

We are members of:

- The EEO Trust
- BusinessNZ and the Sustainable Business Council (SBC), including CEO membership of the Executive Committee of SBC and Landcare Research acting as GRI data partners with BusinessNZ
- Sustainable Business Network
- New Zealand Green Building Council

We are supporters of:

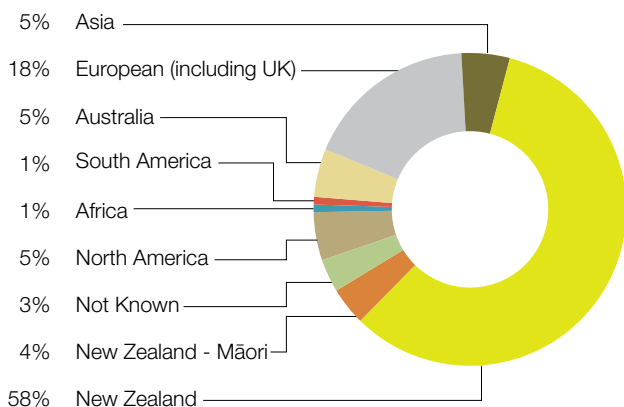
- The Public Service Association (PSA)'s Partnerships for Quality approach

Our People

GOAL Landcare Research has an organisational culture that is adaptive in the face of change, attracts high quality talent, produces great leaders, and is supported by effective systems and processes.

International competition for talented scientists is increasingly fierce, making it a constant challenge for New Zealand research organisations to attract and retain the best and brightest, particularly in the environmental sciences. Our science facilities, culture and our philosophy of ‘manaaki whenua – manaaki tangata’ (care for the land – care for the people) are vital to attracting and retaining staff. Our personnel policies and practices (and those of our subsidiary carboNZero Holdings) comply with ‘good employer’ principles in accordance with section 118 of the Crown Entities Act 2004, but we seek to go well beyond this so that Landcare Research is perceived as an ‘employer of choice’ by our own staff, their colleagues in New Zealand and overseas, and by prospective employees. To this end, our People & Culture strategy focuses on four key areas: Workplace Culture; Leadership; Talent; and Compliance, Systems and Service.

Where our employees come from (self declared)



We always appoint the best person for the job. We have a highly multicultural workforce and we celebrate this diversity. A comprehensive analysis of gender equity in our workplace this year showed no evidence of bias.

KPIs

Leadership, engagement and organisational culture:

- This year, because of the extensive restructuring of our science programmes into Portfolios, our staff engagement survey was postponed. Staff were widely consulted with and formed a key part of the decision making regarding our new science framework, including the number and nature of Portfolios.
- Members of the Senior Leadership Team participated in a 360-degree survey of their leadership styles; feedback and actions were integrated into performance plans.
- The third cohort of tier 3 and tier 4 leaders successfully completed the various modules of our 12-month Leadership Development Programme. The majority of leaders at this level have now completed this programme.

Talent management (turnover of key staff):

- Two of our Senior Leadership Team (tier 2) resigned this year. Two new members were appointed from outside the organisation. At tier 3, no key science staff left. Our new science framework has created opportunities for talented staff to progress into tier 3 roles.

Good employer:

- Our performance is reported in detail online at www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress/our-people
- EEO; gender, age, length of service and pay equity; diversity and commitment to Treaty obligations are covered under Good Employer at www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress/our-people/good-employer

Human resources

| For the year ended 30 June: | 2008 | 2009 | 2010 | 2011 | 2012 |
|--|------|-------|-------|-------|--------------------|
| Total staff (FTEs) in Landcare Research | 394 | 383 | 377 | 379 | 356 |
| In science teams | 288 | 269 | 263 | 261 | 250 |
| - With postgraduate qualifications (Head Count) | 225 | 246 | 210 | 210 | 195 ² |
| In science support | 46 | 45 | 43 | 45 | 44 |
| In general support | 60 | 69 | 71 | 73 | 62 |
| carboNZero Holdings (subsidiary) staff | - | - | - | - | 19 |
| Sirtrack ¹ (subsidiary) staff | 44 | 38 | 40 | 32 | - |
| Women (% science team staff) | 34% | 31.2% | 36.1% | 37.6% | 38.4% |
| Women recruited (% science team staff recruited) | 40% | 42.9% | 38.1% | 62.5% | 48% |
| Māori science staff (HC) | NA | 8 | 10 | 9 | 8 |
| Lost-time injuries | 7 | 6 | 3 | 1 | 1 ³ |
| Days lost per lost-time injury | 2.3 | 1.5 | 1.7 | 1.8 | 40.6 ⁴ |
| Staff turnover | 10% | 12.6% | 9.2% | 14.7% | 11.5% ⁵ |
| Turnover of key senior scientists | 0 | 6% | 0 | 3.4% | 8.6% ⁶ |

¹ Sold to Lotek Wireless Inc. in November 2011

² In addition, 25 science support staff and 15 general support staff have postgraduate qualifications

³ Lost-time injuries per million hours worked = 1.4 (includes injuries where only a part day was lost)

⁴ A fall from a ladder resulted from a momentary decision not to follow the required procedure (to have a colleague stabilise the ladder when on it), which had been adhered to just prior to the fall. Fortunately the injured staff member has now made a full recovery and transitioned back to full-time work.

⁵ Turnover of science staff = 10.2%; science support = 10.6%; general support = 17.4%

⁶ Key senior scientist = Band 6, Science Team Leader or Science GM.

Workplace culture

'Manaaki whenua – manaaki tangata' reflects our environmental research and our attitude to our communities, stakeholders and each other. These values have been particularly evidenced by the compassion and tangible help shown by staff to colleagues and communities affected by the ongoing Canterbury earthquakes. We are committed to being flexible in work arrangements and supporting staff who are affected by the earthquakes or any other difficult circumstances.

In keeping with our EEO commitments, we encourage a 'one Landcare Research' culture irrespective of role, location, ethnicity or gender. Our staff are highly motivated and we have a high level of engagement in what the organisation does and how it is done.

We continue to build our core Māori capacity and bicultural ethos by providing te reo tuition at several sites, and

encouraging staff to participate in courses (some of which are marae-based) covering tikanga Māori and the Treaty of Waitangi. New staff are welcomed and departing staff farewelled with waiata at informal gatherings that are a friendly complement to the formal induction and exit processes.

Leadership

As part of restructuring our science programmes into 10 Portfolios, we appointed 10 Portfolio Leaders (Tier 3 positions), nine of whom were internal appointments and one is a joint position with Lincoln University. Portfolios are flexible, responsive to end-users' needs, reasonably dynamic and the focal point for interacting with key stakeholders. Portfolio leadership is a part-time role, ensuring staff also have time to pursue research.

We manage our science and IT capability within eight teams that report to the Chief Scientist. Teams are the long-term collegial 'home' for staff where they are able

to develop skills and experience, plan career paths, and develop new ideas. The Chief Scientist and Science Team Leaders service the changing capability and capacity needs of the Portfolios. All but one Team Leader were internal appointments. All appointments were based on merit and four of the eight Team Leaders, and five of the 10 Portfolio Leaders are female, which highlights the equitable gender balance we now have.

Talent

In order to develop talent and new research ideas, we invest a subset of our Core funding in inward and outward fellowships, and postgraduate and postdoctoral training. This year we supported a number PhD students (either staff undertaking further study or the PhD study is an integral part of research programmes). We spent \$1788 per FTE (equivalent to 2.49% of our payroll) on direct training, which includes conferences, training courses and further postgraduate study for our staff (but excludes travel allowances). Three technicians benefited from our \$5000 study grant to enable specialist external training that otherwise would be unavailable. We also continue to support our First Foundation Scholar who is now in his first year studying Forestry at the University of Canterbury.

Compliance, systems & service

All staff have access (via our intranet) to our company policies. All staff are given equal opportunities to participate in, and contribute to, employment processes that are transparent, fair, and equitable.

In terms of Health & Safety, we have continued our Tertiary Level status under the ACC Workplace Safety Management Practices programme, and this reflects our very sincere commitment to best practice in field and laboratory work, when handling equipment, and working in the office. Forty-one staff, including six PSA union representatives, have input through health and safety committees at our five largest sites (97.5% of staff).



Michelle Weidner – a Dutch intern on 6-months work experience measuring CO₂ respired from roots, fungi and the soil in the greenhouse gas research facility

Fieldwork is carried out in all weathers and typically in very challenging environments – rugged, remote terrain. We have closely-monitored systems and processes in place to mitigate hazards. In addition, we hold an annual 'field forum' to discuss best practice, emergency management, and other important health and safety issues for working outdoors. The 2012 Field Forum (the fifth one held) was attended by 12 staff.

In addition, employees with any potential exposure to bovine TB through their work have access to a comprehensive medical monitoring programme.

Infrastructure

GOAL Landcare Research's investments in science infrastructure are recognised by scientists as providing excellent science capacity and by Government stakeholders as benefitting New Zealand.

KPI

- It is too early to be able to quantify financial return on investments through science revenue and demonstrable benefit to New Zealand.

Our investments in science infrastructure are aligned to our Statement of Core Purpose, Outcomes and Impacts, and will lead to significant benefit to New Zealand. These investments are strategic and we expected them to bring about a step change over and above 'business as usual' in supporting excellent science.

Our staff make significant contributions to the design of facilities ensuring they are fit for purpose and will meet future needs. Where possible (within the constraints of containment requirements) facilities comply with our sustainability principles, e.g. energy- and water-efficiency and environmentally-friendly fit-out.

Allan Herbarium upgrade

We have completed a \$1.2m investment project at Lincoln to design and install mechanical systems for temperature and humidity control of the Allan Herbarium and associated offices. Investment includes heating, ventilation and air-conditioning systems consistent with international best practice standards to protect the Nationally Significant Plant Collections.

Beever Plant Pathogen Containment Facility

Construction of the custom-designed \$2.15m facility is well advanced at our Auckland site. This facility is a first of its kind in New Zealand. It will enable research on unwanted plant pathogens that have breached biosecurity

border controls, and host-specific pathogens that have significant potential as biocontrol agents for an escalating weed problem in New Zealand. Until now, New Zealand has had no high-level (beyond PC2) containment facilities for plant pathogen research so the investment has significant potential to benefit the country. The Beever Plant Pathogen Containment Facility is named in memory of scientist Ross Beever.

Greenhouse gas research facilities

This year, we opened our new greenhouse gas research facilities at Lincoln, a \$1.6m investment project. The new facilities include significant extensions to laboratories equipped with new state-of-the-art scientific instrumentation. The improved office layout combines open plan with small glass-walled offices to achieve a satisfying blend of quiet and collaborative workspaces for the world-class research group.

New Zealand Arthropod Collection (NZAC)

Part of the collection consists of small specimens stored in ethanol, and these must be kept in a specialist temperature- and light-controlled fire-proof vault. Because NZAC has outgrown existing storage capacity, we extended the existing vault and improved the mechanical ventilation systems. The project was completed in September 2012.

Strengthening buildings & business continuity

Following the devastating Canterbury earthquakes, we commissioned a survey of the structural integrity of our Lincoln buildings. While this showed the buildings are safe to use, the survey identified work needed to improve one building's performance in a seismic event and bring it up to 100% of the new building standard. This work is well advanced and we are carrying out an internal upgrade at the same time.

To improve business continuity responses, we installed an emergency power generator at our Palmerston North site, and also improved the emergency power supply at Lincoln.

Corporate Sustainability

GOAL Landcare Research's corporate performance is exemplary, transparent and consistent with its Vision and Core Purpose.

KPI

- In our on-line reporting, we report our performance using the GRI framework and the set of indicators and methodologies developed with members of BusinessNZ's Sustainable Business to enable benchmarking.

www.landcareresearch.co.nz/about/sustainability

We continue our commitment to increasing the efficiency and sustainability of our procurement practices, and to minimising and mitigating the adverse effects of our activities on the environment. We report comprehensively on this via our sustainability web pages.

Procurement

We collaborate with other CRIs and AsureQuality through the CRI Procurement Forum. Combined savings achieved through this forum exceed \$3m across a broad range of supply contracts, including collective insurance. A new hazardous waste contract, negotiated during 2012, is currently being implemented. The Forum, supported by the Government Procurement Reform and Procurement Advisory Group, is leading negotiations on a syndicated contract for lab consumables. This will be a major initiative for 2013 and has potential to deliver significant savings. We use advantageous All-of-Government (AoG) procurement initiatives to secure contracts for desktop and laptop computers, multi-function print devices, office consumables and vehicles. Contracting through AoG initiatives in legal services, electricity supply and travel are also underway.

Our environmental performance

In keeping with the Sustainable Business Forum's approach, we have committed to improving our environmental performance for a number of KPIs against

a rolling average across the previous five years. However, where the previous year's performance is better than the 5-year rolling average, we use that as the benchmark to improve on in the following year. This approach makes improving our performance more challenging, but we are pleased to report we succeeded for all but one area.

Greenhouse gas emissions

We reduced our total greenhouse gas emissions by almost 13% against the previous year. This is a particularly noteworthy achievement given the additional emission types incorporated (e.g. refrigerants, accommodation nights, compostable waste and embodied emissions in new buildings). The greatest contributing factor to reduced emissions was a 30% reduction in total international air travel kilometres this year. Increased investment in monitoring and managing electricity use, plus upgrades to mechanical plant, also helped contain energy use – pleasing given the extensions to some of our facilities.

Carbon neutrality

AsureQuality, approved verifiers to the carboNZero^{Cert}™ programme, reviewed our systems and records and confirmed that our carbon-neutrality claims meet carboNZero certification standards across all sites. We purchased 2500 carbon credits through the carboNZero programme to offset emissions for the year and achieve net annual emission-neutrality.

Accidental by-catch of native animals

In 11 field projects involving routine pest trapping, 2606 target pests were caught. Two weka were accidentally caught in soft-catch leg-hold traps raised off the ground using 'Scott Boards' but were released unscathed. No native birds or lizards were killed as accidental by-catch in these studies.

The number of target animals caught was the lowest since records began, largely due to the completion of three research projects, which involved catching large numbers of possums, in the previous year.

Summary data

| For the year ended 30 June: | 2008 | 2009 | 2010 | 2011 | 2012 |
|--|------|------|------|--------|-------------------|
| Motor vehicle (km/FTE) | 1690 | 1516 | 1138 | 1660 | 1689 |
| Domestic air travel (km/FTE) | 5289 | 4662 | 4715 | 5634 | 4723 |
| International air travel (km/FTE) | 8594 | 9393 | 9738 | 12,198 | 7756 ¹ |
| Total energy (KWh/FTE) | 8992 | 9238 | 9489 | 8824 | 6504 ² |
| Imputed CO ₂ (tonnes) | 2025 | 3038 | 2556 | 2656 | 2318 ³ |
| CO ₂ offsets | 2390 | 2925 | 2825 | 2679 | 2318 ³ |
| Avoidable waste to landfill (kg/FTE) | 4.15 | 3.12 | 1.25 | 2.12 | 2.52 ⁴ |
| Water used (megalitres) | 8.4 | 10.5 | 10.3 | 11.2 | 9.9 ⁵ |
| Native animals killed through by-catch | 6 | 2 | 0 | 21 | 0 |

¹ Does not include carboNZero or Sirtrack;

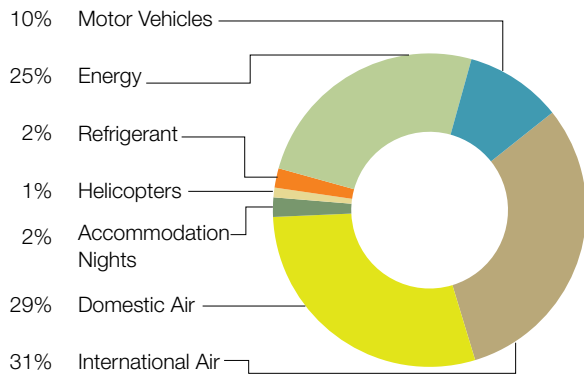
² Decrease largely due to disconnecting from the Plant & Food Research coal-fired boiler for heating one of our buildings

³ Does not include carboNZero or Sirtrack; additional 165 credits purchased for carboNZero and 61 for Sirtrack

⁴ Total waste to landfill was 1.9 tonnes for 2011/12

⁵ This is equivalent to 170m³/\$m revenue for the company for the year

Source of our greenhouse gas emissions (2318 t CO₂)



We produced
39.8 t CO₂e/\$m revenue

We used
58,771 kWh/\$m revenue

Compliance

Our operations are subject to a broad range of legislation covering environmental, good employer (including EEO and Health & Safety), human rights, ethical and financial issues. There were no material instances of non-compliance in 2011/12.



AWARDS

Individuals

- Andrea Byrom - Graeme Caughley Travelling Fellowship from the Australian Academy of Sciences
- David Galloway – elected Foreign Member of The Royal Society of Arts and Sciences - Gothenburg, Sweden, in recognition of his lichenology contributions.
- Ronny Groenteman – IOBC-Asia-Pacific Regional Section Young Scientist Award to attend the 3rd Combined Australian and New Zealand Entomological Societies Conference
- Robert Holdaway – Travel grant to participate in workshop held at the University of Melbourne, Australia, and hosted by the ARC Center of Excellence for Environmental Decisions
- Fraser Morgan – TransAntarctic Association Award to help with travel to Scientific Community for Antarctic Research's Open Science Conference in July 2012
- Marie-Claude Lariviere – A new species of flat bug from New Caledonia was named after her by a world expert in recognition of her contributions to the taxonomy of Hemiptera
- Diana Prada – Queen Elizabeth II technicians' study award to spend time working at the Wildlife Forensics Unit of Alberta in Edmonton (Canada)
- Dan Tompkins – Marsden funding from the Royal Society of New Zealand for research on 'Superspreading and Supershedding - Integrating contrasting hypotheses for infectious disease transmission, emergence and persistence'

- Trevor Webb – Norman Taylor Memorial Lecture awarded by NZ Soil Science Society for 2011
- Janet Wilmshurst – Marsden funding from the Royal Society of New Zealand for research on solving the enigma of prehistoric Moriori settlement on Rekohu (Chatham Islands)

Groups

- Landcare Research's exhibition garden "Transitions", designed by Colin Meurk, won a Gold Award and the Supreme Award for Horticultural Excellence at the 2012 Ellerslie International Flower Show in Christchurch. "Transitions" celebrated greening-the-city opportunities for post-quake Christchurch
- The Central Otago Ecological Trust, chaired by Grant Norbury, won the Supreme Award at the Central Otago District Community Awards
- The carbonZero team won a Green Ribbon award in the greenhouse gas reduction category of MfE's annual environmental awards



SUMMARY OF FINANCIAL PERFORMANCE

Summary of group financial performance

| For year ended 30 June: | 2010 ¹ | 2011 | 2012 | 2012 | 2013 |
|-------------------------------|-------------------|----------|--------------------|--------------------|--------|
| | Achieved | Achieved | Target | Achieved | Target |
| Revenue, \$m | 61.66 | 63.44 | 65.91 ² | 58.42 ³ | 58.96 |
| EBIT, \$m | 2.19 | 2.93 | 2.10 | 2.16 ⁴ | 1.57 |
| EBIT before investment, \$m | 3.03 | 3.91 | 3.60 | 3.34 | 3.34 |
| Investment, \$m | 0.84 | 0.98 | 1.50 | 1.19 | 1.77 |
| Total assets, \$m | 50.31 | 50.91 | 52.87 ⁵ | 45.34 | 47.23 |
| Return on equity ⁶ | 6.4% | 8.4% | 5.3% | 4.9% | 4.2% |
| Dividend \$m | 0.5 | 0.7 | 1.1 | 1.1 | - |
| Equity ratio | 58% | 52% | 52% ⁷ | 56% | 58% |
| Gearing | 12% | 13% | 13% | 0% | 0% |
| Interest cover | 30.9 | 31.3 | 26.8 | 47.5 | 28.3 |

¹ 2010 Return on equity and the equity ratio excludes the impact of 0% building depreciation announced in the Government's May 2010 Budget.

² 2012 Revenue target includes Sirtrack.

³ 2012 Revenue achieved excludes Sirtrack which was disclosed as a discontinued operation due to the sale of the business in November 2011.

⁴ 2012 EBIT achieved excludes Sirtrack as this was disclosed as a discontinued operation as a result of the sale of the business in November 2011.

⁵ 2012 Total assets target has been adjusted by adding back deferred tax liability (original SCI target 49.2).

⁶ 2012 Return on equity target is lower because we planned significant reinvestment in the organisation. 2010 and 2011 return on equity excludes extraordinary restructuring costs.

⁷ 2012 Equity ratio target has been adjusted to calculate on averages rather than closing values (original SCI target 55%)

Revenue:

Includes science research, subsidiaries, contract work for government and commercial clients, royalties, licence fees etc., plus income from the sale of product and the lease of assets. It excludes income from gain on sale of subsidiaries and interest on investments and from finance leases, \$0.9m for 2012.

EBIT:

Earnings before interest and tax, and after committed business development expenditure and commercialisation expenditure.

Return on equity:

NPAT ÷ average shareholders' funds, expressed as a percentage. NPAT is net profit after tax. Shareholders' funds include share capital and retained earnings.

Equity ratio:

Average shareholders' funds ÷ average total assets.

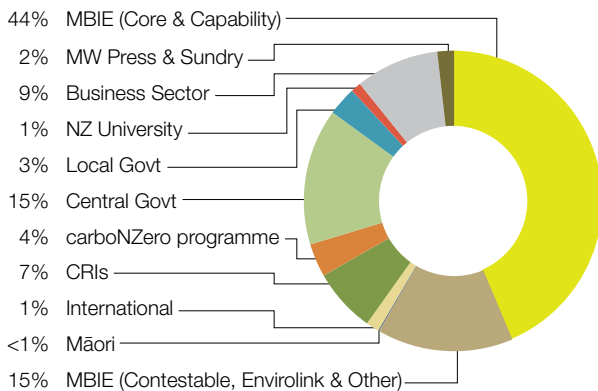
Gearing:

Financial debt includes all interest-bearing liabilities. Gearing = interest bearing debt ÷ interest bearing debt plus shareholders' funds, expressed as a percentage. (The Minister of Finance and the Minister of Science and Innovation each hold 50% of the shares on behalf of the public.)

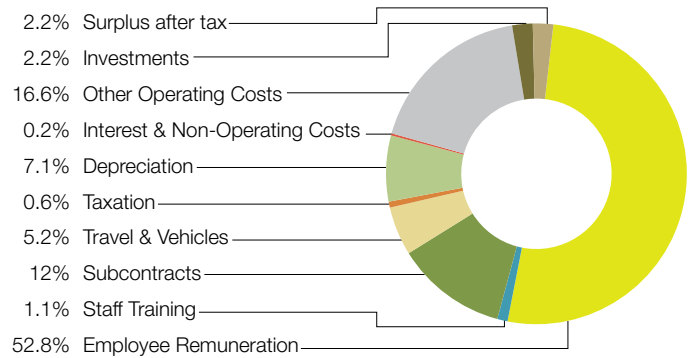
Interest cover:

Interest is the cost of debt and financial leases. Interest cover = EBITDAF ÷ interest. (EBITDAF is EBIT before depreciation, amortisation and fair value adjustments.)

Revenue by Source



Where our revenue goes



Where our revenue comes from

- Ministry of Business, Innovation and Employment's (MBIE) Science + Innovation Group Core funding 44% – includes capability funding to maintain existing skill and to develop new science capability
- MW Press & sundry 2% – Manaaki Whenua Press is our natural history and science book publishing and retailing business centre
- Private & business sector 9% – principally contracted work for businesses and industry organisations
- Universities 1% – contracted services, some paid lecturing by our staff, and rentals for university staff located in our buildings
- Local government 3% – contracted work for regional, district and city councils
- Central government 15% – services contracted by government departments including DOC, MfE and MPI
- The carboNZero programme^{Cert™} 4% – which provides certification services for greenhouse gas reduction and mitigation
- CRIs 7% – research subcontracted to us in collaborative programmes
- International 1% – development projects funded by donor agencies, international consultancy projects
- MBIE contestable funding sources 15%

Where our revenue goes

- Investment 2.2% – support for technologies and services including those advancing through our commercialisation pipeline
- Other operating costs 16.6% – includes electricity, carbon credits, software licences, insurance, consumables, and lease costs
- Interest & non-operating costs 0.2%
- Depreciation 7% – includes accounting depreciation on buildings, science equipment and computers
- Travel & vehicles 5.2% – all vehicle and air travel by our staff, including the cost of leased vehicles. Landcare Research runs a mixed fleet of vehicles including 4WD and quad bikes for fieldwork, and cars and vans for road use
- Subcontracts 12% – research subcontracted to other research providers, including CRIs and universities in collaborative research programmes
- Staff training 1.1% – includes conferences, training courses and support for postgraduate study (2.49% of the total payroll)
- Employee remuneration 52.8% – includes staff in management, science, support roles, business development and carboNZero Holdings

DIRECTORY

DIRECTORS

Jo A Brosnahan QSO (Chair, to 30 June 2012)
Dr Chris Downs (From 1 July 2012)
Prof. W Grant Guilford (Resigned 28 March 2012)
Gavan J Herlihy
Hon. M John F Luxton QSO
Dr Emily J Parker
Peter M Schuyt (Chair, from 1 July 2012)
Tania J Simpson
Victoria A Taylor

SENIOR LEADERSHIP TEAM

Dr Richard FS Gordon: Chief Executive Officer (From 25 May 2011)
Dr Rob B Allen: Acting General Manager, Science & Policy
Carol R Bellette: Chief Financial Officer and Company Secretary
Katrina F Direen: General Manager, People & Culture
Dr Libby G Harrison: General Manager, Development
Dr Phil BS Hart: General Manager, Science Investment & Evaluation
Rau Kirikiri: Kaihautū (part time)
Dr Peter Millard: General Manager, Science & Industry
Dr David Whitehead: Chief Scientist

CORPORATE (REGISTERED) OFFICE

Canterbury Agriculture & Science Centre
Gerald Street
PO Box 40
Lincoln 7640
New Zealand
Phone +64 3 321 9999
Fax +64 3 321 9998
Website www.landcareresearch.co.nz
Email <surname><initial>@landcareresearch.co.nz

BANKERS: The National Bank of New Zealand

AUDITORS: Audit New Zealand on behalf of the Auditor-General

SOLICITORS: Buddle Findlay

Where You Can Find Us:

ALEXANDRA

43 Dunstan Road
PO Box 282
Alexandra 9340
Ph: (03) 440 2930

AUCKLAND

231 Morrin Rd, St Johns
Private Bag 92170
Auckland 1142
Ph: (09) 574 4100

DUNEDIN

764 Cumberland Street
Private Bag 1930
Dunedin 9054
Ph: (03) 470 7200

LINCOLN

Gerald Street
PO Box 40
Lincoln 7640
Ph: (03) 321 9999

GISBORNE

ZG FM Building
Grey Street
PO Box 445
Gisborne 4040
Ph: (06) 863 1345

HAMILTON

Gate 10
Silverdale Road
Private Bag 3127
Hamilton 3240
Ph: (07) 859 3700

WELLINGTON

6th Floor, Equinox House
111 The Terrace
PO Box 10345
Wellington 6143
Ph: (04) 382 6649

NELSON

First Floor
24 Nile Street
Private Bag 6
Nelson 7042
Ph: (03) 545 7700

PALMERSTON NORTH

Riddet Road, Massey
University Campus
Private Bag 11052
Palmerston North 4442
Ph: (06) 353 4800

CARBONZERO HOLDINGS LIMITED

21 Falcon Street, Parnell
PO Box 137182
Parnell 1151
Auckland
Ph: (09) 574 4152
(Registered Office)
Gerald Street
PO Box 40
Lincoln 7640
Ph: (03) 321 9999

Landcare Research New Zealand Limited
(Manaaki Whenua)
Annual Report 2012

Part 1:

Non-financial section
ISSN (print) 1172-7942
ISSN (web) 1177-9969

Part 2:

Directors' Report and Financial Statements
ISSN (print) 1172-9996
ISSN (web) 1173-0277

ANNUAL REPORT 2012

Our Annual Report is in two parts—together they fulfil our annual reporting responsibilities under the CRIs Act 1992. Detailed information about our research, operational activities and governance is available on our website:

www.landcareresearch.co.nz

Glossary

| | |
|----------------------|---|
| AHB | Animal Health Board |
| BCG | A vaccination against tuberculosis |
| BusinessNZ | New Zealand's largest advocacy group for enterprise |
| CABI | CABI is a not-for-profit international organisation that improves people's lives by providing information and applying scientific expertise to solve problems in agriculture and the environment. |
| CEMARS | Certified Emissions Measurement and Reduction Scheme |
| CRC | Cooperative Research Centre |
| CRI | Crown research institute |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation (Australia) |
| DairyNZ | DairyNZ is the 'industry good' organisation, representing New Zealand's dairy farmers |
| DCD | Dicyandiamide, a nitrification inhibitor |
| DNDC | Denitrification-decomposition computer simulation model |
| DOC | Department of Conservation |
| Ecosystem services | The 'free' services that healthy ecosystems provide e.g. clean water, fertile soil, storm water retention, erosion prevention |
| Environmental limits | The point at which ecosystem services collapse, e.g. the soil's biological community is depleted to the extent that they can no longer replenish nutrients |
| FAO | Food and Agriculture Organisation of the United Nations |
| Kaitiakitanga | Traditional guardianship of natural resources |
| KPI | Key Performance Indicator |
| LINZ | Land Information New Zealand |
| Mātauranga | Traditional cultural knowledge |
| MBIE | Ministry of Business, Innovation and Employment (formed from a merger of the Ministry of Science and Innovation with other government departments) |
| MFAT | Ministry of Foreign Affairs and Trade |
| MfE | Ministry for the Environment |
| MPI | Ministry for Primary Industries (previously Ministry of Agriculture and Forestry, and Ministry of Fisheries) |
| MSI | Ministry for Science & Innovation; now part of MBIE |
| NGO | Non-governmental organisation |
| NLRC | National Land Resource Centre |
| NZAGRC | New Zealand Agricultural Greenhouse Gas Research Centre |
| PGgRc | Pastoral Greenhouse Gas Research Consortium |
| SLMACC | Sustainable Land Management and Climate Change |
| S-map | Digital soil map for New Zealand |
| SPREP | Secretariat of the Pacific Regional Environmental Programme |
| TB | Tuberculosis |
| TFBIS | Terrestrial and Freshwater Biodiversity Information System |
| TPK | Te Puni Kōkiri |
| ZESPRI | The kiwifruit marketing board (not an acronym) |

Photo Credits

| | |
|-------|--|
| PG 2 | Foyer of the Fleming Building, Lincoln <i>Cissy Pan</i> |
| PG 7 | The silver fern, a symbol of New Zealand <i>Cissy Pan</i> |
| PG 8 | Chris Morse, Ella Hayman and Kate Ladley in Waitutu <i>Caroline Thomson</i> |
| PG 14 | Canterbury Plains and Waimakariri River <i>John Hunt</i> |
| PG 20 | Dairy cows on irrigated pasture <i>Phil Suisted</i> |
| PG 26 | Diamond-certified OfficeMax is Enviro-Mark's largest multi-site member <i>Cissy Pan</i> |
| PG 31 | Sam Carrick (left) explaining channel lysimeters to (L-R) Mark Kibblewhite* (Cranfield University, UK), Ross Monaghan (AgResearch soil scientist), Emily Parker (Landcare Research Director), Pete Millard with back to camera, Andrew Campbell* (Darwin University, Australia), Phil Hart and Graeme Martin (CEO, Otago Regional Council) *Science Advisory Panel <i>David Whitehead</i> |
| PG 34 | Carving in one of our Lincoln buildings <i>Cissy Pan</i> |
| PG 36 | Senior and early career soil scientists from across Landcare Research at a team planning and development workshop in Northland <i>Scott Fraser</i> |
| PG 43 | Bug-eye view of connected computer banks <i>Robert Gibb</i> |
| PG 46 | Carolyn Hedley (right) discussing precision irrigation at an industry conference workshop <i>Adrienne Farr</i> |
| PG 50 | Grace Hall explaining invertebrates to the general public at BioBlitz 2012 <i>Chester Nicholls, Sweetshots</i> |
| PG 57 | Part of our award winning exhibition garden at the Ellerslie International Flower Show <i>Cissy Pan</i> |

Cover stock: Curious Skin, sourced from well managed forests, ECF free
 Inside paper stock: Cocoon Offset, 100% recycled, ECF free

**ANNUAL
REPORT
2012 PART I**



Landcare Research
Manaaki Whenua