

Landcare Research New Zealand Limited
(Manaaki Whenua)
Annual Report 2011

Science and Environment for a Better New Zealand
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ANNUAL REPORT 2011

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 impacts, and governance is available on our website:

www.landcareresearch.co.nz

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Prominent role in new Global Soil Map initiative

GlobalSoilMap.net



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LANDCARE RESEARCH AT A GLANCE



Our Vision

Science and environment for a better New Zealand

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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 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 land 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

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Our Organisation

We are 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 Minister of Science and Innovation.

We have approximately 400 staff at 10 locations across New Zealand, including our subsidiaries Sirtrack at Havelock North and carboNZero^{Cert™} at Lincoln and Auckland.

Sustainability is embedded throughout our organisation and evidenced in both our research focus (science for sustainable outcomes) and our day-to-day operational activities. It's not just about what we do but how we do it – and add value to society and the natural environment. We report comprehensively on this at www.landcareresearch.co.nz/sustainability/

Our science revenue (approximately NZ\$65 million per year) is derived primarily from contracts with the Ministry of Science and Innovation (MSI), Ministry for the Environment (MfE), Ministry of Agriculture and Forestry (MAF), 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 the sense that the environment is inextricably linked to economic, societal and cultural well-being. Māori are tangata whenua, the indigenous people of Aotearoa New Zealand, with whom we consult and collaborate.

www.landcareresearch.co.nz

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Chair Jo Brosnahan

CHAIR & CHIEF EXECUTIVE'S REPORT



Chief Executive Dr Richard Gordon

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It is a pleasure for us to introduce Landcare Research's Annual Report for 2010/11. The year has brought challenges, including the terrible earthquakes and aftershocks that have occurred in Christchurch, close to our headquarters at Lincoln where half of our 400 staff are based. But the year has also brought opportunities from the reform of the government-owned Crown Research Institutes (CRIs), of which we are one of eight. This Annual Report for 2010/11 complements our Statement of Corporate Intent 2011–16, available on our website, which sets out our goals and strategic initiatives for the next five years.

In spite of the disruptions, we achieved favourable financial outcomes for the year. Our return on equity was 8.4% (target 7%); the full-year earnings before interest and tax (EBIT) for the Parent were \$3.248m (target \$2.888m) and for the Group (including our subsidiary, Sirtrack) were \$2.928m (target \$3.048m). Science and business revenue grew by 3% and cost savings across the Parent contributed to these positive results. The solid performance gave us confidence to invest earnings in additional science capacity and facilities, including new greenhouse gas research laboratories and equipment (page 38). We are proud that these results were achieved in an environment in which the earthquakes caused around 1500 lost staff-working-days while staff attended to damage at home and in their communities. We are grateful to our clients and science partners who accommodated our need to modify contract dates.

Canterbury's ongoing earthquakes and the major events in Japan and South America remind us that society is ultimately at the mercy of nature. Where we can, we have

to nurture this relationship by seeing the environment as an asset, not merely a resource. The earthquakes also elicited a strong social response – what we call *manaaki tangata*, caring for the people – which reminds us of the importance of social capital and the need to nurture those relationships. Landcare Research stands at the interface of the environment, society and the economy, seeking to understand the complex relationships and finding ways in which those can be nurtured to achieve sustainable prosperity.

The Government's CRI reform was the first significant review since the CRIs were set up in 1992. A major output, the Statements of Core Purpose, has given each CRI a greater clarity of outcomes and connections. Landcare Research is now clearly accountable for contributing towards four national outcomes, working especially with government, industry and Māori organisations, for being the leader amongst CRIs in certain areas of science, and for collaborating with other science providers in other areas (see page 2).

The reform has encouraged us to adopt collaborations in which we will align our resources with those of science users (government, industry, Māori organisations) to achieve national outcomes. This has been facilitated by the award of core funding from the Ministry of Science and Innovation (MSI) to CRIs, giving Landcare Research discretion over the allocation of 40% of our total revenue (up from 10% in previous years). The balance of 60% remains subject to our clients' contestable processes. We are fortunate in having had experience of significant collaborations through the Outcome-Based Investments (OBIs) in the biodiversity and biosecurity areas. Those OBIs are now being reformed

In a recent global survey, Thomson Reuters assessed the scientific publication record of organisations conducting environmental research over the period 2001–11.

The ranking, assessing the impact of science papers through the number of times they are cited by

other scientists, put us 1st in New Zealand and 3rd in Australia and New Zealand combined. Landcare Research was placed 37th in the world, after Australia’s Macquarie University (14th) and James Cook University (35th). Chicago University was placed 1st and Oxford University 36th.

to align with the new model, but using similar principles of resource alignment between stakeholders.

We have made significant contributions to national outcomes during the year. Working with the Department of Conservation (DOC) and regional councils, we have contributed to development of a regional biodiversity monitoring framework (page 11). This will be an important tool as government implements a national biodiversity strategy. Contributing to sustainable land use, we have made many of our soils and land data readily available through web portals (page 31) to help land managers make better decisions about land use. We have also developed new methods for improving water-use efficiency and reducing contaminant losses to groundwater (page 16). In the area of greenhouse gases and carbon, our work has contributed to a better assessment of changes in soil carbon stocks through soil erosion and respiration (page 19); while in the area of sustainability (development within limits) we have conducted the first water footprint assessment for kiwifruit and trialled new ways to engage society and science in debating complex issues – in this case the redevelopment of Christchurch (page 23).

Relevance and excellence are essential components of the contribution our science makes in achieving national outcomes. Science excellence is measured by our peers in the global science community who assess the value of our contribution to knowledge through our publications being accepted in highly ranked science journals. It is pleasing that an independent global survey by Thomson Reuters ranked Landcare Research 1st amongst environmental research institutes and universities in New Zealand based on science publication numbers

and impact during the decade 2001 to 2011. This result reflects the quality of our scientists and of our national and international science collaborations. This interaction is the lifeblood of our capability building and keeps us at the forefront of global science.

Growing science excellence and capability depends on strong international connections. In many of our areas of science (e.g. greenhouse gas science), there is heavy competition for science talent globally. By strengthening our international linkages, we keep our science at the global leading edge and make Landcare Research better known and attractive as a New Zealand employer. Increasingly we will be seeking international science revenue through our global partners. During 2010/11, we have strengthened our scientific relationships in China and the Americas (page 28), and our science and business revenue in Australia, Europe and the Americas.

One of Landcare Research’s strengths is its multidisciplinary make-up and ability to integrate not only across science areas but also across the economic, environmental, social and cultural dimensions of contemporary issues. We also integrate across spatial scales from paddock to region to national and global, and across time frames from prehuman history in New Zealand to the future. Our fourth national outcome is *the integrator*, in which we develop projects and solutions that combine those different dimensions for the benefit of private and public organisations who face increasingly complex, multi-faceted challenges. An example is the development of economic pest control methods that minimise environmental impact and meet social and cultural requirements (page 25). Vision Mātauranga attempts to realise the potential of Māori through innovation and using

traditional knowledge. Our byline – manaaki whenua, manaaki tangata – reflects the connection between the environment and the people. The Māori worldview sees all life as inextricably connected with the environment. During the year, we have invested in bringing these approaches together in the context of conservation management. We have led groups to meet First Nations people in Canada and Australia to share experiences of such management, and to recognise the complementary strengths of the contrasting approaches. We also have worked with Māori groups to help them convey their holistic viewpoints in resource management planning processes (page 17); and we have developed the Māori land-use visualisation web-tool based on a partnership with Te Puni Kōkiri and the Ministry of Justice. This web-tool is designed to help realise the economic potential of Māori-owned land through making its features and capabilities better understood.

The CRI reform recognised the need for CRIs to contribute to economic growth through innovation. We have a number of areas of technological development (page 32) for some of which we will be seeking private-sector development partners. We also await development of national models for supporting technology transfer.

Our business unit, carboNZero^{Cert™}, certifies greenhouse gas emissions, management and offsetting for organisations. In 2010/11 it grew its net revenue by 29% across five countries, and passed the milestones of 500 certifications, over 230,000 tonnes of carbon dioxide offsets, and 44 million tonnes of emissions under certified management. On 1 July 2011 the operations of carboNZero were transferred to a separate company, wholly owned by Landcare Research, with Graham Carter as the new CEO.

Our business unit Ecogene[®] provides DNA diagnostic services especially for wildlife. Its business has grown impressively during the year, contributing amongst other diverse projects to identification of the PSA disease affecting kiwifruit during 2011. Our Sirtrack and Invasive Species International businesses have suffered difficult export conditions but held up well in spite of those.

Twelve years ago, we put ourselves on a 'sustainability journey', publishing a report of our sustainable development that set a benchmark for our performance against social, economic and environmental goals and measures. Our sustainability performance is documented on our website www.landcareresearch.co.nz/sustainability. Our operations are carbon neutral through continued efforts to reduce our

footprint and the purchase of offsets, which puts a price on carbon in our financial accounts. We invest in greener building and facility design, and waste and water reduction. We also invest in social capital, developing our staff, keeping them safe, assisting our communities, and in 2010, started the sponsorship of a First Foundation scholar in his last year of school and throughout his undergraduate years (page 37).

Our greater sustainability challenge, as we recognised in our first sustainable development report in 2000, is to work with our partners to achieve sustainable prosperity in New Zealand. Our staff are passionate about making a difference through their science. As we enter a new financial year, we see the institutional settings that will help us achieve that goal. However, we recognise that the lingering impacts of the economic crisis will put pressure on science spending in both public and private sectors.

We wish to thank our partners in government, industry, science and the wider community who give us their support. We thank our own people whose dedication and professionalism underpin our value to society as an organisation.

We acknowledge and thank Dr Warren Parker, our CEO until 21 February 2011, who led the organisation since 2005. He is now CEO of Scion Research, bringing his skills to science for the forest industry. We also farewell and thank Graeme Boyd, who has been a director with Landcare Research for the past six years.

We especially thank our 200 staff at Lincoln who have endured three major earthquakes and over 8000 aftershocks since September 2010. Some have lost their homes and/or friends, and many have suffered damage to property and livelihoods. We will continue to support them and also use our science to support the recovery efforts for the Canterbury community. In particular, we welcome efforts to rebuild the city using low impact urban design principles and to bring science organisations closer together in finding sustainable and integrated solutions for agriculture, business and the environment in the Canterbury Region.



JO BROSNAHAN
CHAIR



RICHARD GORDON
CHIEF EXECUTIVE

Strategy & Performance

► Alignment with our partners

Landcare Research's goals and priorities are strongly aligned with those of our major stakeholders (our Government owners) and clients (the Department of Conservation (DOC), Ministry of Agriculture and Forestry (MAF), Ministry for the Environment (MfE), Animal Health Board (AHB), regional councils and business sectors) – to meet their strategic and operational needs. Through iwi partnerships, we support Māori economic development plans and the guardianship of their natural assets.

Implementation of the CRI Taskforce recommendations, especially with respect to finalising our core purpose and key science outcomes, involved extensive government and business end-user engagement. This has important implications for us and we have proactively addressed these in our Statement of Corporate Intent 2011–16. www.landcareresearch.co.nz/about/documents/sci1116.pdf

► Our approach

- Focus on growing the prosperity of New Zealand across the dimensions of economy, society, culture and environment.
- Be proactive in developing evidence-based solutions to our stakeholders' present and future challenges.
- Use an integrative approach to creating solutions that bridge sectors, scientific disciplines, and mātauranga Māori, across both landscapes and timescales.
- Address complex environmental problems with appropriate techniques, while we are proactive about the evolving role of science in society.
- Achieve high standards of science excellence and knowledge sharing to cultivate New Zealand's critical science capability, through careful stewardship of our own capability and knowledge assets.

Strategic Initiatives for 2010/11

► Financial performance

We said we would: Increase financial resilience to meet shareholders' expectations and enhance scope for reinvestment

How we performed:

- We achieved an 8.4% return on equity, which exceeded the target of 7%; and we have identified strategic opportunities for reinvestment in science and infrastructure.
- Our financial performance is summarised on pages 40–41, with the full financial statements presented in Part II of our Annual Report.

► CRI Taskforce

We said we would: Proactively work with key stakeholders to maximise the opportunities for Landcare Research and New Zealand from the Taskforce's recommendations

How we performed:

- Our key stakeholder partners were involved in helping us develop our SCI 2011–16. The independent client survey showed that stakeholders familiar with the CRI Taskforce reforms are unanimous about the proactive way in which we handled this process.
- We are part of 7 national collaborative research centres and members of 7 national research networks.
- 41 staff held 133 positions on national and international advisory boards, technical groups and review panels; 11 staff hold 17 directorships or board memberships.

► International engagement

We said we would: Build and strengthen international networks to access new ideas, top talent, funding and larger-scale opportunities

How we performed:

- Of 349 co-authored papers published during the year, 344 had overseas co-authors from 42 countries.
- 138 papers were presented at overseas conferences.
- 33% of our staff are from overseas; 25% of scientists recruited this year were from overseas.
- Significant opportunities were identified through the Global Research Alliance, the EU-funded Knowledge Based Bio-Economy (KBBE) Forum, the Chilean Government's science agency CONICYT, the Chinese Research Academy of Environmental Sciences and the New Zealand and China Environmental Cooperation Agreement.

► Reinvestment of surpluses

We said we would: Accelerate the creation of national benefit by increasing the competitiveness of Landcare Research's science and shortening lead times of new knowledge and technologies to market

How we performed:

- We are working to establish a National Centre for Land Resources to bring together data from within Landcare Research, other science providers and government and industry, and to develop eResearch applications to transform access to and usability of data.
- The new greenhouse gas research facilities at Lincoln will support research for MAF and MfE to assist New Zealand in meeting its international obligations to report and reduce greenhouse gas emissions, and strengthen our position as a leader in such research.
- We are partners in National e-Science Infrastructure (NeSI), a \$48 million investment by government, three universities and two other CRIs to build and operate four interlinked High Performance Computing facilities.

► Customers, communication and branding

We said we would: Achieve superior understanding and interaction with our customers and key stakeholders to secure revenue growth targets and maximise national benefit of our RS&T

How we performed:

- In an independent survey, all of our clients interviewed rated our performance as 'excellent' or 'very good' (2010: 91%); all agreed our staff were highly professional (2010: 95%) and worked effectively with clients (2010: 81%); and all rated the quality of our research as 'excellent' or 'very good' (2010: 95%).
- We participated in the EnviroLink-organised Regional Council Roadshow to 15 regional councils and territorial authorities.
- We continued 6-monthly CEO and senior management team meetings with each of our major clients in government to foster greater collaboration and strategic alignment in our work.
- \$11.15m (18% of our revenue) was contracted from government departments, local government and the Animal Health Board; New Zealand private-sector clients contracted \$6.16m (10% of our revenue) in research services; we produced 223 contract reports for clients.
- 69 client staff were on our advisory groups, and 38 staff held 66 positions on stakeholder advisory groups.
- We were invited to participate in 252 technical meetings with client and stakeholder staff.
- We worked on collaborative research projects with 195 end-users and stakeholders.
- We produced 16 different newsletter series (print or online), each specifically focused on the needs of particular client and end-user groups. In the external client survey, several stakeholders commented positively about the tailored newsletters and appreciate the short, sharp and relevant information on our work.
- We share premises with 119 client and stakeholder staff across 9 of our sites.

► Environmental technologies

We said we would: Develop and transfer products and services that improve the sustainable use of natural resources and environments and expand economic opportunity

How we performed:

- The carboNZero programme increased its net revenue by 29% from last year, and signed a licensing agreement with Lloyds Register Quality Assurance Ltd in Australia (the second CEMARS licensing agreement for Australia). From 1 July 2011, the business became a wholly owned subsidiary company with its own CEO and Board of Directors.

- EcoGene® flourished with a 72% growth over the previous the year; EcoGene's Technical Director won the annual 'Women in science entrepreneur award' from Pacific Channel.
- Enviro-Mark membership grew by 8% last year; 31 training workshops, seminars, drop-in sessions and member networking events were provided to members.
- Our commercial technology pipeline has 8 technologies at the prototype stage (1 of which has patent protection), 11 technologies in developmental stages, and 6 undergoing commercial testing (1 of which has patent protection).
- Detailed economic case studies are available at: www.landcareresearch.co.nz/publications/casestudies

► Systems, workplace and infrastructure

We said we would: Provide a flexible, modern work environment with best practice in organisational sustainability and smart working solutions

How we performed:

- External audits confirmed retention of our ISO 14001 Environmental Certification, the tertiary (highest) level of the ACC's Workplace Safety Management Programme, and our carbon-neutrality in accordance with protocols and processes required by the carboNZero programme.
- All refurbishments and new builds used environmentally friendly materials; our new greenhouse gas research facility used Green Star principles in the absence of Green Star ratings for a building of this nature.
- We progressed our ICT strategy to enable staff to access our internal networks and systems 'anywhere-anytime'; we participated in the Broadband-enabled Science and Technology Grid (BeSTGRID) to develop New Zealand's eResearch infrastructure; and worked with the University of Auckland to establish the Tuakiri New Zealand Access Federation, which simplifies access to high performance computing resources.
- We reduced our GHG emissions by 4% and energy consumption by 8% compared with 2009/10, but international travel increased by 26% and domestic travel by 28%.

► People, performance and culture

We said we would: Develop an organisational culture that is adaptive to changing environments, attractive to high achievers and supports high quality and enduring partnerships with key clients and research collaborators

How we performed:

- The quality of our staff is evidenced by publication of 243 papers in journals with formal peer-review, 9 books edited or co-edited, 24 book chapters, 169 conference papers and abstracts, and well over 150 non-refereed journal articles and popular publications.
- A review published in *Ecological Monographs* by three of our staff and nine others was evaluated by the Faculty of 1000 as a must-read new finding and review. This evaluation places the work in the top 2% of published articles in biology and medicine, and this is the second consecutive year in which this group has published a 'must read' paper.
- In their annual review of research, FRST rated progress in four contracts as 'Gold' (outstanding).
- Thomson Reuters' global survey of scientific impact (citations per paper 2001–2011) ranked us 1st in New Zealand, 3rd in Australasia, and 37th in the world.
- 210 staff in science teams have postgraduate qualifications; 23 science support and 18 general support staff have postgraduate qualifications.
- 6 staff hold joint professorial roles with universities; 29 staff hold 36 honorary university positions; and staff supervised 71 PhD and Masters students.
- 48 staff (including research associates) held 59 positions in professional societies (14 Fellows); 46 of our senior scientists (including research associates) held 96 positions on the editorial board of scientific journals.
- 11 staff were invited to give keynote or plenary addresses at significant national and international conferences, with costs fully or partly covered; in total, staff made 287 paper and poster-paper presentations at conferences and technical workshops.
- 19 postdoctoral researchers were hosted, 5 of whom commenced during the year.
- The third and final cohort completed our in-house year-long leadership development programme; feedback has again been very positive.
- 71.5% of our staff participated in the staff engagement survey, which was higher than the CRI benchmark. We scored favourably in health and safety, flexible workplace, sustainability practices and 'manaaki tangata' values; the survey also highlighted several areas for improvement.
- We formed a Joint Graduate School with Auckland University to enhance the science relevance and 'job readiness' of biodiversity and biosecurity candidates.



BIODIVERSITY

Outcome

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

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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.

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 delivery efficiency and policy effectiveness.

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

Impacts

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

Core Expertise

- Biosystematics and nationally significant biological collections
- Terrestrial and freshwater ecosystems
- Environmental assessments, management and monitoring
- Invasive species management, control and eradication
- Bio-informatics and integrative modelling
- Environmental resource economics
- Policy advice and evaluation

Highlights

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.

► Understanding ecosystem retrogression

Chronosequences (a locality where soils span a sequence of ages) provide valuable insights into ecosystem development over thousands to millions of years. An international project team, led by Landcare Research, reviewed and synthesised research from across many disciplines to better understand the causes and ecological consequences of retrogression. The review revealed that there are predictable, coordinated shifts in vegetation and soil communities and ecological processes during both ecosystem progression and retrogression, with phosphorus more important in the long term than nitrogen. Similar patterns of retrogression occur in areas with vastly different climatic regimes, geologic substrates, and vegetation types, even though the timescales and mechanisms driving retrogression may vary greatly among sites. Studies on retrogression also provide evidence that, in many regions, high biomass or 'climax' forests are often transient, and do not persist indefinitely in the absence of rejuvenating disturbance.

The review was selected as a 'must read' by the Faculty of 1000 Biology: *'This review brings new clarity to the overall scheme of ecosystem development over long time periods, sheds new light on the importance that phosphorus has played in shaping the Earth's ecosystems, and unifies previously disparate analyses of ecosystem retrogression.'*

► Comprehensive new classification system for forest and shrubland

More than 70% of New Zealand's forest and shrubland has been lost in the 800 years since human arrival, through fire, land clearance and logging. Remaining forest and shrubland continues to be modified and lost (through, for example, invasive species and land-use change), so an up-to-date depiction of the composition, extent and structure of these woody communities at a range of scales is urgently needed. Researchers used the LUCAS (New Zealand Land Use and Carbon Analysis System) network (1177

vegetation plots positioned on an 8 km x 8 km grid across the country) to identify 24 different broad vegetation classes, termed 'alliances'. Each alliance was evident in 19–105 plots, with each comprising an estimated land area of 144,000–794,000 ha. Stand structure data suggest that 16 of these alliances are largely stable whereas eight will undergo compositional change; the new classification system will be invaluable in managing that change.

Previous classifications and vegetation maps were either out of date, too broad, or didn't accurately depict the actual vegetation. The new classification also highlights the extent of disturbed landscapes where alliances are compositionally dynamic, and being invaded by exotic species. These are areas with high potential for future carbon sequestration and biodiversity enhancement, but which are poorly understood.

► Naturally uncommon ecosystems

'Naturally uncommon ecosystems' are included in the Ministry for the Environment (MfE)'s priorities in developing the National Policy Statement on Biodiversity. We were commissioned by MfE to determine the level of spatial overlap between naturally uncommon ecosystems and LENZ threatened environments, which are also one of the national priorities. The wide range of overlap between the two classification systems provided a good example of how the proposed statement uses complementary criteria to identify areas of potential biodiversity value.

Different types of naturally uncommon ecosystems cover total areas ranging from less than 100 ha to more than 10,000 ha, with protection status varying from none (almost solely on private land) to extensive (mostly on public conservation land). It is imperative that overall intactness and the condition of each naturally uncommon ecosystem is assessed to indicate threat status, which is critical for policy implementation.

► Regional councils' biodiversity monitoring framework

Following our work with the Department of Conservation (DOC) to develop a national biodiversity monitoring and reporting framework, adopted by DOC in June 2010, we have been working with regional councils to agree on a suite of indicators for a regional-scale monitoring of the condition and trend in terrestrial biodiversity.

Over the next two years, we will begin developing the tools that enable all regional councils in New Zealand to report consistently on terrestrial biodiversity, contributing to a more scientifically sound and informative picture at the regional scale, with data integrated more readily with DOC's work at the national scale and State of the Environment reporting by MfE. The framework will assist councils to assess the effectiveness of different policy and regulatory approaches, decide where to allocate limited resources and provide greater accountability for rates expenditure, and make improvements to the protection of indigenous biodiversity.

► Biodiversity of dryland environments

Dryland environments contain some of the most transformed, least protected and most threatened native ecosystems and species in New Zealand; only 3% is legally protected. Protection versus land use intensification is hotly debated and long-term monitoring studies provide important evidence for policy decisions.

The 1000 ha of dryland tussock grassland in the Tekapo Scientific Reserve is the only sizeable place where stock have been absent and rabbits and wilding pines controlled to low levels for nearly 20 years. When it was destocked in 1992, the land was highly degraded and denuded, being dominated by bare ground and mouse-ear hawkweed (*Hieracium*). Permanent grassland plots established a monitoring baseline against which changes could be compared. This year with DOC, we resampled these plots plus some additional areas. After 18 protected years, the resurgence of tussocks and other palatable native species, including several rare and uncommon species, has been astonishing.

Further evidence that removing grazing benefits dryland biodiversity is coming from studies on land retired from pastoral use through Tenure Review. Sites that are still grazed were compared with equivalent sites where grazing ceased 10–30 years ago. Ungrazed sites had significantly greater native vegetation richness and fewer exotic species, more native shrubs and taller shrub cover than was found at the grazed sites.

Research supports increased legal protection of these important environments before widespread land-use intensification and irrigation cause irreversible changes.



Helene de Meringo

Rowan Buxton & Richard Clayton sampling dryland biodiversity

► Tūi returning to Hamilton

Recently completed biennial bird counts in Hamilton showed a three-fold increase in the incidence of tūi visiting the city compared with two years ago. This confirms the effectiveness of peri-urban pest control, which is mostly undertaken by Environment Waikato based on Landcare Research advice. A decade of research showed tūi mainly visited urban and rural areas in the winter. They nested in native forest remnants on the fringes of the Waikato Basin but their nesting success was poor; ship rats and possums were the main cause of nesting failure. Intensive control of ship rats and possums has clearly increased tūi abundance in the wider Waikato, including Hamilton City.

Impact 2

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

► Mokihinui Restoration Project

The Mokihinui Restoration Project (MRP) is a large-scale, long-term ecological restoration project initiated by Solid Energy and DOC to see if extensive wild animal control produces detectable gains in carbon stocks. The MRP will cover 18,600 ha of native forest and other natural vegetation in the North Branch of the Mokihinui River,

North Westland. At Solid Energy's request, we reviewed the project design with Resource Consultants Ltd. We identified a number of significant weaknesses. To remedy these inadequacies, we provided Solid Energy with a scientifically robust monitoring framework that is (1) capable of detecting reasonable changes in carbon sequestration within the project area, and (2) able to demonstrate the magnitude of any 'additional' gains attributable directly to the management intervention. We recommended that further plots were established to monitor potential changes in areas of regenerating vegetation not currently sampled. To enable the separation of carbon gains due to wild animal control from background changes in carbon, we recommended they establish appropriate experimental control 'non-treatment' plots, and analyse existing datasets (e.g. LUCAS) where appropriate.

The MRP project is internationally novel and contributes to New Zealand's obligations to conserve and enhance carbon sinks under the United Nations Framework Convention on Climate Change. This ongoing project is an excellent opportunity to investigate the potential for private-industry-funded animal (ungulate) control to result in carbon sequestration as well as biodiversity gains on public conservation land.

► Possum control reduces tree mortality

Introduced possums are one of the most significant pests in New Zealand's indigenous forest but how much and how quickly forests respond to possum control is (surprisingly) not well understood. Between 1996 and 2004, researchers measured the increase of possum populations after aerial 1080 poisoning, and how possum-preferred tree species responded to those changes. Possum densities, much reduced after poisoning, usually recovered quickly to near pre-control levels within six years. The overall mortality of possum-preferred tree species was about 25% lower at poisoned sites compared with unpoisoned sites, although this varied between species. Canopy condition of some of the most common and widespread species such as kāmahi, māhoe and tawa continued to recover even when possum numbers had substantially recovered. The results initially suggested that reducing possum density by 60% (modest by today's standards) would protect most possum-preferred trees, but more detailed analysis of kāmahi mortality indicated that some individuals in some areas would remain vulnerable.

► Biocontrol of tradescantia

Tradescantia is a serious environmental weed throughout much of New Zealand and other countries. The first releases of the tradescantia leaf beetle as a biocontrol agent, a global first, were made in the Auckland Region earlier this year; with further releases in Northland, Bay of Plenty, Waikato and Manawatu-Wanganui. The releases follow an intensive 2-year programme to rid the rearing colony of a gregarine gut parasite. This project is collaborative with DOC and the National Biocontrol Collective (including the Auckland Council).

The Environmental Protection Agency (formerly ERMA) also approved the release of two additional agents for tradescantia (the tip beetle and stem beetle).

► Joint management of traditional land

A number of settlements and claims under the Treaty of Waitangi represent major changes in land tenure and natural resource management in New Zealand. Landcare Research is working with several iwi on options for conservation land management and governance.

A study tour to Australia's Northern Territory (with participants from Tūhoe, Ngātiwai, Ngā Puhi, Avonside Girls High School and CSIRO) examined joint management models on traditional-owner lands. Specific areas of interest included understanding the leasing, governance, and management structures used; and evaluating the benefits accruing to traditional owners from joint management. It was clear that, over a number of decades, some joint management models are achieving some goals (e.g. protecting areas) but fall short on others (e.g. employment of traditional owners).

The similar study tour to Canada involved Landcare Research, University of Canterbury and Te Kotahi a Tūhoe. The group met with the Kativik Regional Government (a non-ethnic regional government that supports both Inuit and non-Inuit aspirations) and the Nunavik Land Holding Corporation. This visit provided a useful contrast to the Australian situation.

The challenge is to draw from these overseas models to develop local capacity and conservation management approaches that fulfil iwi aspirations.



LAND RESOURCES

Outcome

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

14

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 resources sustain the essential services such as primary production, ecosystem services (e.g. clean water, fertile soils) and aesthetic benefits upon which New Zealand's economy, identity and brand are based. Achieving the appropriate management of these resources is a major economic opportunity for New Zealand.

Effective management of land resources requires improved knowledge of their variability and change over time and across catchments and landscapes (natural, managed and urban), their response to human impacts, and potential environmental limits. Improving knowledge assets will help ensure land and its ecosystem services are sustainably allocated and used.

Impacts

1. The status and trends of land resources and ecosystem services (including their interactions) are known and understood.
2. Opportunities and threats to land resources are recognised and balanced to maintain or enhance the provision of ecosystem services.

Core Expertise

- Soil characterisation, soil functions and processes
- Land-use capability and impacts
- Integrated catchment management and hydrology
- Erosion processes
- Nutrient and contaminant fate
- Land and soil informatics, including remote sensing
- Ecosystem services
- Resource economics and policy
- Mātauranga Māori and societal values in land resource decision-making

Highlights

Impact 1

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

► S-Map online

<http://smap.landcareresearch.co.nz>

During the year, staff worked on a new software platform, based on open standards and open source software, for visualising data and for querying datasets. The first application of this work focuses on the new national soil dataset S-map, providing easy-to-use interactive soil maps, information about soil classes or attributes, options to customise high-quality soil maps for printing, and downloadable soil factsheets for specific locations. We will continue to work with users to ensure S-map delivers value, for example to territorial authorities (for policy development, monitoring programmes and consent rules), rural agencies and farm managers (for management, planning and standards certification), and science research programmes (for modelling and scaling up of research results).

► Mapping irrigated land

During the year, researchers also produced an updated map (a data layer in geographic information systems) of irrigated land, based on the Ministry for the Environment (MfE)'s national database of resource consents. The data show regions with the greatest irrigation pressure (e.g. Canterbury) and can be used by local authorities to manage water allocation and water quality issues.

Impact 2

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

► NZ-FARM Regional Model

Landcare Research has developed the New Zealand Forest and Agriculture Regional Model (NZ-FARM) that optimises potential rural income across a catchment against the environmental impacts of land use (pastoral, arable, horticultural, forestry, scrub or conservation) and land-use

and management change. It takes into account greenhouse gas emissions from agriculture and forestry, forest carbon sequestration, water use and water constraints, and nutrient (nitrogen and phosphorus) and pesticide losses. The model was originally developed for the Hurunui/Waiapu and Manawatu catchments; additional catchments will be added as data become available. Work is currently under way to include additional ecosystem services such as pollination.

The primary intent is to provide decision-makers with information on the economic impacts of environmental policy and how policy targeting one issue could affect other environmental and economic issues (e.g. how a cap on nutrient loading could affect greenhouse gas emissions and vice versa). NZ-FARM has been used to assess the benefits and impacts of:

- Increases in water storage from capital improvement projects
- Proposed caps on nitrogen and phosphorus loads
- Implementation of NZ-ETS on the forestry and agricultural sectors
- Regional afforestation schemes
- Implementation of new farm technology and best management practices
- Increases in farm input costs and/or output prices

► Reducing sediment in the Manawatu River

Many rivers in the Manawatu-Wanganui region are silt-laden because of hill-country erosion. Sediment reduces flood capacity, spoils aquatic habitat, and degrades water quality. Horizons Regional Council's Sustainable Land Use Initiative (SLUI) encourages soil conservation in the most vulnerable, highly erodible land by subsidising farmers for targeted erosion control work, such as forestry, land retirement, and soil-conservation tree planting. SLUI will spend up to \$80 million in the Manawatu-Wanganui region.

To help plan and assess progress in SLUI, we have developed a model to assess the impacts of farm plans on sediment yield. Sediment yields can be estimated for the present day, for 2020, and for the target date when all farm plans have been implemented and are fully mature. By 2020, about half of the target reduction (25–50% depending on which river) should have been realised.

These data are being used in mediation discussions with stakeholders in the Manawatu River Accord. Future improvements to the model will use more comprehensive measurements of erosion and sediment transport as part of 'Clean Water Productive Land' research.

▶ Leaky soils affect water quality

Pastoral agriculture in New Zealand has many benefits but can also impact water quality. Fertiliser use and animal excreta may increase nitrogen in waterways, promoting the growth of algae and microbes, and degrading aquatic habitat and recreational values. To help understand the extent of the problem and restore water purification services from the soil, we have developed national models of nitrate leaching and dissolved reactive phosphorus leaching to predict what happens anywhere in New Zealand. These models, based on OVERSEER®, cover most soil-climate combinations in New Zealand, and are responsive to stocking rates. Results are expressed as leaching rates per stock unit, with leaching maps produced at 1:50,000 scale.

The regions with the highest leaching values were Northland, Waikato, Bay of Plenty, Manawatu-Wanganui, and Canterbury. Leaching rates are clearly driven by both rainfall and soil type, and need to be taken into account when planning land use. Shallow soils with high rainfall will have excessively high leaching rates that necessitate special mitigation measures. Land managers and policy analysts will be able to use the models to assess the effects of policy intervention or land management on ecosystem services (clean water).

▶ The fate of nutrients in soils

We have three complementary projects focused on understanding the fate of nutrients in the soil. Understanding and quantifying of leachates are essential to managing runoff and reducing the nutrients reaching groundwater, waterways and lakes.

Standard lysimeters to measure the fate of effluent on stony soils: Many years of research show how different soils respond to dairy shed effluent applied to the soil's surface. Landcare Research produced a general map for all of New Zealand showing where soils are 'leaky' to microbes or retained within the soil, but this map revealed a lack of knowledge about what happens in stony soils, many of which are being converted to dairying.

Standard lysimeters – hand-carved cores of undisturbed soil in purpose-built barrels – have been collected from the Mackenzie Basin. In the laboratory, these will be irrigated with dairy effluent and artificial rainfall, and the leachate analysed for microbial indicators.

Large scale *in situ* lysimeter array near Lake Taupo: This is a more direct approach quantifying the impacts of land-use practices and amelioration treatments, such as use of biochar, on reducing the nitrogen entering Lake Taupo. Water in the lake is deteriorating due to nitrogen, of which 30–40% comes from pastoral farmland. Waikato Regional Council has a target of reducing manageable nitrogen entering the lake by 20%, and is exploring nitrogen trading markets as a mechanism to help achieve this. Cut-and-carry lucerne may be an economically viable, low nitrogen-loss option but the effectiveness needs to be quantified.

To provide these data, a specially designed and manufactured lysimeter array has been installed on the western side of Lake Taupo. Each of the 12 lysimeters contains an undisturbed 1-m-diameter soil core 1.5 m high, which weighs about 1.2 tonnes, with the surface of each planted and treated in four different combinations of lucerne, industry standard fertilisers, biochar, and ryegrass/clover. Leachate is analysed for nitrate, ammonium and phosphate. Rainfall, air temperature, soil temperature and level of leachate in the tanks are being telemetered hourly back to Landcare Research at Hamilton. The research will extend for at least three years.

Channel lysimeters: These are another innovative *in situ* design with the potential to provide direct feedback to farmers enabling them to modify irrigation schedules, optimising water use and minimising water leaching down into groundwater. Channel lysimeters are inserted horizontally into soil about 1.5 m below the ground surface and just above the water table.

Following a prototype developed and tested at Lincoln, four channel lysimeters have recently been installed, with regional council support, on two dairy farms with stony soils in Central Otago. Irrigation efficiency, both in terms of water and effluent application and impact on leachates, will be monitored from spring (start of the milking season) through summer. The lysimeters and soil moisture sensors are connected to a wireless sensor network supplying real-time data over the Internet, which will enable farmers to tune the efficiency of their irrigation systems. The data will also aid



Installing lysimeter casings at the large-scale array near Lake Taupo

Otago Regional Council in developing policy and resource consenting, and add to research knowledge about the fate of effluent in stony soils.

► Web-based tools to support Māori resource management

Māori land visualisation tool:

<http://whenuaviz.landcareresearch.co.nz>

Māori need better and easier access to quality land resource and environmental information when making decisions about their land. With funding from Te Puni Kōkiri (Ministry of Māori Development) we have developed an interactive web-based tool that provides basic land resource information and summary statistics for each registered Māori land block. A pilot version of the tool, shown at a series of conferences and workshops last year, generated huge interest around the country. This year, the tool was released widely for public comment.

It combines updated Māori land block data (property and legal) from the Ministry of Justice with environmental and land resource data from Landcare Research; it is also linked to the National Library's DigitalNZ records, giving a wealth of additional historical and archival information. Data is displayed over topographic maps, satellite imagery and aerial photographs. It has been designed specifically for Māori land owners and land managers wishing to explore the nature of their land and identify sustainable and potential land use. At this stage it gives a coarse assessment of land type matched to suitability for horticulture, cropping, pastoral farming, forestry, and areas needing long-term protection.

The Māori land visualisation tool should be of enormous benefit to Māori land owners and Māori organisations such as trusts and incorporations, and many government departments.

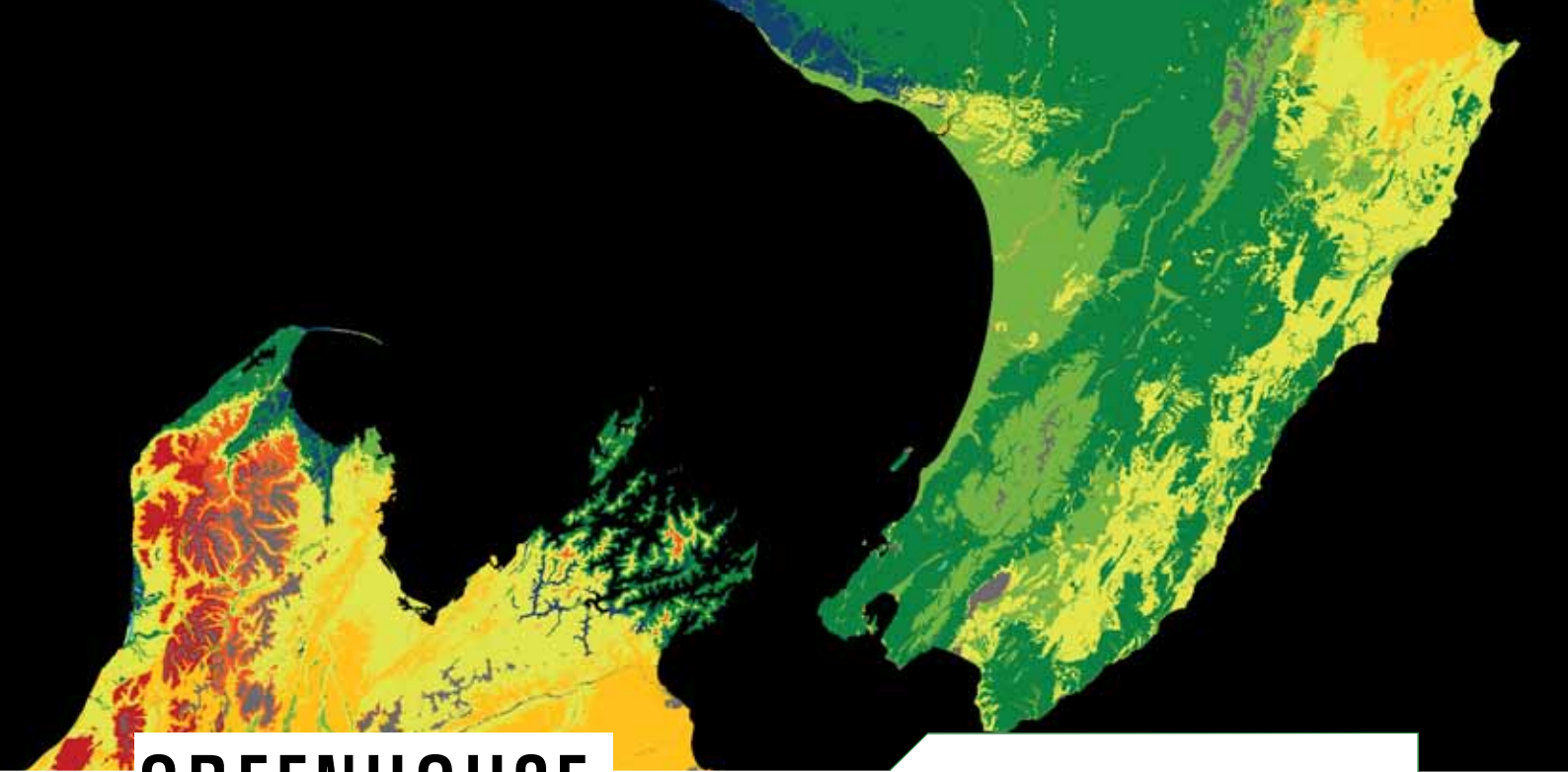
Resource management framework for Māori:

<http://www.rmfmf.net.nz>

We have developed a pilot web-based resource management framework (RMF) that provides Māori resource managers with better access to information about statutory obligations and responsibilities in relation to stormwater in estuaries. This work has been carried out in collaboration with Te Ao Mārama Inc. (Southland) and Mana Ahuriri Inc. (Hawke's Bay) and addresses concerns expressed by Māori resource managers about the difficulties in navigating the complex legislative landscape of natural resource management.

The RMF tool enables users to understand the implications of relevant legislation (e.g. the Resource Management Act and regional policy statements) on their local areas and to find information that will help in responding to requests for resource use. Other key attributes of the RMF tool include the potential to adapt the framework for use on other environmental issues (e.g. water extraction or pest control) and the transferability of the tool to other regions beyond Southland and Hawke's Bay.

Importantly, the site captures mātauranga from local Māori RMA practitioners (in particular Morry Black of Ngāti Kahungunu, Ngā Raurū and Ngāti Porou) and allows for this knowledge and wealth of experience to be accessed by a wider group of end-users than previously possible. This will have lasting benefit to Māori.



GREENHOUSE GASES



Outcome

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

18

Rationale

New Zealand must meet its international greenhouse gas reporting obligations and decrease net emissions of greenhouse gases from terrestrial systems 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.

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.

Impacts

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

Core Expertise

- Land use impacts on net greenhouse gas emissions
- Carbon sequestration (sinks) in vegetation and soils
- Modelling regional- and national-scale emissions budgets
- New mitigation technologies and strategies
- Evaluation of policy options

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.

► Managing and projecting changes in carbon storage by native forests

Projections of expected changes in the amount of carbon stored in our forests are required for New Zealand's ongoing climate change negotiations. Detailed empirical (observed) data and supporting modelling exist for exotic production forests but the information for indigenous forests is much less clear. To remedy this, the Ministry of Agriculture and Forestry (MAF) contracted us to improve understanding of (1) carbon currently stored in native vegetation, (2) the rate at which carbon accumulates at present ('business as usual'), and (3) how 'management' options could optimise carbon sequestration in native forests.

Human-induced disturbance (e.g. logging, clearing, and burning) has produced a significant shift in the composition and age-structure towards young or regenerating forest types. Such forests are likely to have less carbon on average than forests affected by purely natural disturbance (e.g. storms, earthquakes). While the natural disturbance is unavoidable, proper forest management could remove the effect of human disturbance.

LUCAS (the Land Use and Carbon Analysis System) data from the National Vegetation Survey (NVS) Databank was used to quantify the actual carbon stocks by current vegetation type and by region. Calculations take into account carbon in live biomass of tree stems, branches and roots; standing dead stems, coarse wood debris, and shrubs. Each of the >1300 plots was measured between 2002 and 2007.

The effect of human disturbance on total carbon content is being quantified with a complementary mix of plot measurements and satellite data. Plot-based variables include the presence/absence of grazing (managed stock only), clearing, mining, fire, logging, and the presence of tracks. From the data we can assess the level of 'naturalness' of the vegetation cover at each location.

Data are being integrated to model potential carbon stocks in the absence of all such disturbances.

Our research will consider the scale at which optimal management could maximise gains or minimise losses in carbon sequestration (beyond current management) over the next couple of decades. This will help MAF to make an informed decision about 'business as usual' sequestration in indigenous forests, what actions are needed to increase the sequestration to optimal levels, and what the risks of reversals are.

► Modelling the carbon sink potential of New Zealand's exotic forests

In a significant project for MAF, we modelled wood productivity of *Pinus radiata* across New Zealand in response to the wide range of environmental variables that affect tree growth and carbon accumulation. The model generates 'productivity surfaces' (similar to a contour map – see facing page) for the whole country, showing in unprecedented detail the regions with expected high and low productivity. These predictions corresponded extremely well with actual measurements in stands of different ages.

Stand productivity was found to be particularly sensitive to mean annual temperature, with 12–15°C being optimal, and to annual precipitation, 500–2000 mm being optimal. Currently, temperatures are generally sub-optimal for growth, and precipitation sub-optimal. Soil fertility was generally adequate for most sites. Highest productivity was modelled for the moderately wet, warm northern and western regions of the North Island, and lowest for cold sites at higher elevation, for the dry eastern areas of the South Island, and the extremely wet sites on the West Coast of the South Island.

Simulations under likely future climatic conditions suggested increases in productivity of 15% by 2040 and 25% by 2090.

► Revisiting carbon losses from soil

Soil respiration is the largest source of carbon dioxide (CO₂) from terrestrial ecosystems, equivalent globally to 10 times that produced by burning fossil fuels. Therefore, any change in soil respiration with soil and climate warming

could have a major impact on the rate of global warming. However, understanding soil respiration is complex because the CO₂ comes from two distinct components (respiration of roots and associated soil microbes; and decomposition of soil organic matter and litter) that might respond differently to warming.

Previous studies have suggested that the temperature response of organic matter decomposition in undisturbed soils might vary from that measured by laboratory incubations. Using a novel stable isotope technique to measure the two components of respiration in an undisturbed soil under young radiata pine trees, we found respiration from roots increased as the soil warmed but decomposition of soil organic matter did not. However, in laboratory incubations of disturbed soil, soil organic matter decomposition was sensitive to temperature.

The results imply that current models of terrestrial carbon dynamics overestimate future losses of CO₂ from undisturbed soils, at least in the short term, and hence are likely to lead to overestimation of the rate of global warming.



John Hunt

Measuring the components of soil respiration

Monitoring System (CMS) model. All of the eroded plots we sampled had significantly lower soil carbon stocks than comparable plots with no erosion. Furthermore, the loss of soil carbon persists for a long time – 70 years after the landslide occurred, soil carbon stocks were still well below the value measured for no erosion plots (by c. 40% for scars and 20–30% for debris tails).

Gully erosion has a minor effect on soil carbon stocks because gullies generally only occupy a small portion (<5%) of the landscape.

Further work on landslides is needed in parts of the country that have a long history of landsliding, and which have had significant post-1990 storms, to refine models of soil recovery on landslide scars and debris tails. This would complement work to establish a national overview of the land area affected by landsliding each year.

► Ammonia from animal excreta

Gaseous ammonia (NH₃) is emitted (volatilised) from animal excreta as the urea content breaks down. Some of this NH₃ is redeposited elsewhere and transformed into other nitrogen compounds, including nitrous oxide (N₂O); hence NH₃ emissions are accounted for as 'indirect N₂O emissions' in greenhouse gas inventories.

The value of the volatilised fraction of excreted nitrogen (the emission factor) used in New Zealand's greenhouse gas inventory was recently reduced, as recommended by a review for MAF in 2008. To obtain further data to support this decision, MAF funded a 2.5-year paddock-based project to measure NH₃ emissions from cattle excreta. We led the project in partnership with Lincoln University and AgResearch. In the first experiment, cattle urine was

► Forestry changes in New Zealand 1990–2008

Forestry changes were assessed for the Ministry for the Environment (MfE), using LUCAS, firstly, to document the methods and uncertainties of the LUCAS land use mapping project, and secondly, to collate land-use-change data 1990–2008 to help assess conditions and trends of ecosystem services.

Between 1990 and 2008, 75,000 ha (± 6%) of land were deforested and 579,000 ha (±2%) were forested; the change sequestered 140 million emission units of carbon. If the trends continue through the Kyoto commitment period, the sequestered carbon due to forest change will be worth \$150 million per year to New Zealand.

Afforestation is taking place in hill country in the North Island, which has extra benefits for erosion control. In the South Island afforestation is evenly spread around the regions, except Tasman and Westland. Deforestation is primarily taking place in the central North Island due to conversion to dairy farming.

► Accounting for the effects of erosion in the soil CMS

Landslide erosion has a significant effect on soil carbon stocks and needs to be accounted for in the soil Carbon

applied in a regular pattern of patches; in a second, urine and dung excreted by cattle over three days were left *in situ*. We estimated emissions from measurements of concentration of NH₃ at five heights in the paddock and at one height upwind.

The volatilised nitrogen fractions were similar in both experiments. Volatilisation from dung peaked later and amounted to a smaller fraction than that from urine. Both experiments were conducted at the warmest time of the year and the emissions were high, but our findings support the continued use of the present emission factor.

The implications are that our findings support the reduction in reported N₂O emissions by 5%, or c. 600,000 tonnes CO₂-equivalent. At an assumed trade price of \$25 per tonne CO₂, this would represent a saving of \$15 million in greenhouse gas emission liabilities.

Impact 2

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

► Methane biofilters for dairy effluent ponds

We have been developing and testing methane biofilter technology to reduce emissions from farm dairy effluent ponds. For about 20 months and with minimal maintenance, a prototype methane biofilter has been successfully consuming >95% of the methane in biogas from a covered effluent pond at a Massey University dairy farm. This work confirmed that selected methanotroph (methane-eating bacteria) communities in an appropriate medium with adequate air supply can function efficiently through all seasons. However, preliminary measurements from a Southland farm show limited application for cattle wintering barns because methane concentrations were too low for our current filter design.

We are now beginning to test a second biofilter prototype, at the Massey University dairy farm, that is intended to provide optimal methane consumption at minimal cost. Over the next year, we will be optimising filter performance, then we will focus on encouraging activity of the most active methanotrophs.

Interest in the methane biofilter has come from DEFRA in the UK, and Pork Australia in Sydney. Through collaboration

with the University of Western Sydney, we have been invited to join a consortium to tackle Australian cattle emissions, using biofilters.

► Regional GHG inventory framework used in planning

Wellington City Council (WCC) has adopted and advanced our regional greenhouse gas inventory framework and emissions profiles for potential 2020 scenarios. We worked with the WCC to develop potential scenarios around trends in population growth, GDP, fuel use, transport (including airport expansion), energy prices, and energy generation mix. The work demonstrated potentially large variations in the city's emissions profile – a 90% national renewable energy target decreased Wellington City emissions by 67%, a 3% rise in GDP increased emissions by 47%. The 'ground-breaking' results have been used to educate councillors on the impact of current trends and development strategies and in the development of the Wellington City Climate Change Strategy and Wellington 2040 Strategy. The use of scenarios in developing local climate change strategy has attracted attention from other councils.

► Climate change and Māori land business opportunities

Of the 1.5 million hectares of Māori land (half of which is marginal for farming), 37% could be eligible for Kyoto forest and a further 15% has potential for reversion to scrub and forest. We collaborated with Gisborne-based 37 Degrees South Aotearoa to identify climate change business opportunities and critical success factors for Māori-owned land. Of opportunities identified, Māori ranked carbon-forestry sinks as highest priority, followed by land-use change and land-use flexibility. Other options were energy and renewable energy from sustainable wood products; energy efficiency, biodiversity and environmental services; and lowest priority, nutrient use and budgets, measurement technologies, anaerobic digestion, methane, and nitrous oxide abatement.

Climate-related business opportunities, such as new carbon afforestation and biofuels projects, could generate hundreds of millions of dollars into the rural and Māori economies, including much needed new jobs. Afforestation and reforestation on marginal lands in the Gisborne–East Coast Region of the North Island would also have a large number of environmental benefits such as providing greater resilience for landscapes and communities in the face of any increased incidence of extreme weather events.



SUSTAINABLE INDUSTRY, BUSINESS & ORGANISATIONS

Outcome

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

22

Rationale

To achieve sustainable economic development, New Zealand must work within environmental limits and be responsive to the needs of local communities (licence to operate), the cultural context of Māori world views, and commercial markets (licence to sell and being competitive). These challenges are increasingly complex with no 'right answer' for resolving high-risk and polarised viewpoints. They bring together the community, the public sector as regulators and policymakers, the private sector as the economic engine, and the science sector as the provider of trusted evidence and innovation on which policies, strategies and solutions may be built.

Research is needed to better understand the factors required to resolve complex environmental issues, adapt to global change, and reduce vulnerability to resource scarcity. Solutions need to integrate economic, social, cultural and environmental dimensions; and they may be applied within communities, marketplaces, governance structures or individual organisations.

Our capability and collaborations have developed over the last decade in response to the changing role of science in society, and the growing interests of society in the global issues of climate change, food security and competition for natural resources and biodiversity loss.

Impacts

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

Core Expertise

- Strategic foresight thinking in government and business
- Sustainability as a factor in business competitiveness
- Managing wildlife vectors of human and livestock diseases
- Biocontrol of productive-sector weeds
- Integrating economy, society, culture and environment in policymaking
- Mātauranga Māori in Māori business development
- Resilience, adaptiveness and eco-innovation in communities and infrastructure
- Strategies for social and organisational adaptation to climate change

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.

► Review praises the ICM programme's approach

In late 2010, a panel (comprising academic, international, regional council and Māori representatives) completed an end-of-programme review of the Motueka River Integrated Catchment Management (ICM) research. Landcare Research partnered with the Cawthron Institute and Tasman District Council to lead the research, which also involved NIWA, GNS, Scion, NZ Landcare Trust, Te Tau Ihu iwi and the community. The ICM programme scored 5/5 for Science Quality & Productivity, 4/5 for Impact on Catchment Management & Policy Development, and 5/5 for Knowledge Transfer, with the panel recommending similar approaches be used across the country to manage competing expectations for limited land, water and coastal resources.

Councils, government, Māori and sector groups from across New Zealand were similarly positive. They revealed a widespread desire to move from the adversarial effects-based approach of the Resource Management Act, to a collaborative approach built on community trust, as documented at <http://icm.landcareresearch.co.nz> and in a 2011 special issue of the *New Zealand Journal of Marine & Freshwater Research*.

► Magnetic South – for Christchurch's recovery

Magnetic South was an online discussion about the long-term future opportunities for Christchurch following the highly damaging earthquakes of 2010/11. It used the Foresight Engine, courtesy of the Californian Institute for the Future, to generate a fast flow of almost 9000 ideas from 850 people. Popular broadcaster Kim Hill featured Magnetic South on her Saturday morning radio show. This led to an overwhelming surge in public participation, swamping the US-based servers and forcing an earlier than expected end after 27 hours – called 'epic-win-for-online-participation-silicon-valley-server-munted' in the final blog.

Magnetic South revealed a genuine community desire for an environmentally sustainable city that attracts talent and investment.

We released the data under a Creative Commons Attribution 3.0 New Zealand Licence. The information complements the Christchurch City Council 'Share an Idea' initiative. Magnetic South collaborated with StratEDGY, and was supported by Christchurch City Council and the Mayor Bob Parker. Plans for future events include more boutique crowd-sourcing events (perhaps no more than 500 people) on quite specific issues in more focused environments.

► Economic modelling for global change and trade

Policymakers increasingly want economic models to guide how primary production and international trade should respond to climate change. However, technologies for large-scale modelling of production, emissions and responses in the primary sector are still in their infancy because they require particularly complex integration of economic and biophysical data and processes.

In partnership with the University of Chicago and Argonne National Laboratory's Computation Institute, we are investing in developing a new, dynamic, spatially detailed model. The complementary and multidisciplinary skills will contribute significantly to the innovative and ambitious research project.

► Wildlife diseases – individuals to ecosystems

While infectious diseases and parasites obviously affect individual wildlife hosts, they also have an impact at the ecosystem scale. An important challenge is to determine the key transmission mechanisms maintaining the persistence of different types of diseases in the wild. Good evidence now shows that both direct and indirect effects of parasites frequently mediate the success of invasive species and their impacts on recipient communities. Such interactions may offer key insights into when and how different regulatory factors are important, when disease can cause species extinctions, and what characteristics are indicative of functionally resilient ecosystems.

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.

► Water footprinting green kiwifruit

The Ministry of Agriculture and Forestry (MAF) and ZESPRI International commissioned Landcare Research to assess the water footprint of green kiwifruit supplied to the UK — the environmental impact of water used, directly and indirectly, throughout all stages from growing the fruit through to it reaching the consumer. The project, a partnership with Plant & Food Research and AgriLink, was the first-ever comprehensive water footprinting exercise to be carried out in the New Zealand horticulture sector.

At the orchard gate, green kiwifruit have an average water footprint of 417 litres per kilogram of fruit. Using this national average, 85% is water available for fruit growth from rainwater or soil moisture, 5% is from irrigation, and 10% is used to dilute orchard inputs, e.g. nitrogen fertiliser entering the environment. However, several regions made a relatively low contribution to national production yet had relatively high environmental impacts. Hypothetically converting irrigated orchards into rain-fed orchards had a significant impact on water footprints for only the low-rainfall areas (Hawke's Bay, Gisborne and Nelson), but significantly reduced orchard gate returns for Hawke's Bay and Nelson. In the Te Puke region, neither the application of



Green kiwifruit orchard. We also contributed to the identification of PSA disease affecting kiwifruit.



Bruce Foster

Anthony Hume & Carla Coelho, who led the kiwifruit water footprint study

fast-release nitrogen fertiliser nor halving of the amount of nitrogen fertiliser typically applied had a significant influence on the water footprint.

The research has been of considerable value to ZESPRI, as major global retailers, such as Walmart and Sainsbury's, are paying increasing attention to water footprints across suppliers worldwide. MAF will use the results in formulating New Zealand's responses to development of the ISO water footprinting standard.

► Beech forest production systems

New Zealand has a wealth-creation opportunity through building an industry based upon the sustainable management of a portion of its 1.5 million hectares of privately owned indigenous forests, including 300,000 ha owned by Māori. Sustainable management of privately owned indigenous forests for high-value timber products requires management systems that have limited impact on the environment. In the last year, our research improved the confidence of forest owners and managers to adopt the management systems we have researched.

Beech (*Nothofagus* spp.) is the main indigenous forest managed for timber production in New Zealand. Perceived difficulties around stand stability and regeneration following harvesting have long limited the development of a beech timber industry. We reviewed management systems prescribed in the 1993 amendments to the Forests Act 1949 for beech forests, and concluded that in most places beech regenerates following harvest and that residual beech stands are usually stable.

Beech trees grow slowly, and stands regenerating from past felling develop into dense even-aged thickets of saplings and pole-sized trees where individual growth rates are in the order of 2 mm in stem diameter per year, with expected rotations of more than 120 years. However, beech saplings respond well when freed from neighbouring competition.

We remeasured two thinning trials set up in the 1970s. Stem diameter of 58-year-old beech trees in thinned areas was about double that of trees in the unthinned stands; potential sawtimber yields were up to 7 or 21 times higher compared with unthinned stands. An initial discounted cashflow analysis (undertaken with the University of Canterbury) for silver beech stands indicated that, while thinning operations are currently unprofitable for timber production, revenue from trading carbon credits could offset thinning costs.

► Sustainable possum harvesting

Possum harvesting in accessible areas of native forest is a balancing act. Sufficient animals need to be trapped for commercial viability and to protect the forest, but if too many animals are killed the operation will not be sustainable. Working with full-time possum harvesters and using our extensive information about possum behaviour and control, we are developing an economic model that considers variations in trapping effort, possum density and economic variables. Together with Tūhoe Tuawhenua Trust, we are determining the optimal trapping frequency and trap-line spacing for sustainable harvests. We are also investigating the links between post-harvest possum densities and benefits for forest biodiversity. This work is likely to lead to further research of benefit to Māori land owners and the possum fibre industry.

► Strategies for reducing bovine TB spread

In New Zealand, four wild mammal species are frequently infected with bovine tuberculosis (TB), but possums are the only true 'maintenance' host. Red deer, ferrets and pigs are generally 'spillover' hosts that become infected from possums. Spillover hosts may occasionally transmit infection back to possums ('spillback'). Spillback transmission is potentially far more epidemiologically important than its low frequency of occurrence might suggest, as deer, ferrets and pigs can spread TB far more widely than possums; and persistence of TB in long-lived deer extends the risk of spillback far into the future. Reducing the number of deer to very low levels would be controversial and expensive. Although the risk of spillback is undoubtedly low, it may nonetheless determine the minimum scale and duration of possum management required. The current strategy for eradication of TB aims to keep possum numbers low for 5–10 years longer than would be necessary if possums were the only TB host involved, thus eliminating spillback risk.

► Biocontrol of weeds of pastoral weeds

Over 2010/11, 115 releases of eight control agents were made against broom, gorse, tradescantia, woolly nightshade and thistles. ERMA (now the Environmental Protection Authority) also approved the release of an ultra-specific control agent for Chilean needle grass (*Nassella neesiana*), which is harmful to stock. The debilitating rust is so specific that Chilean needle grass from the North Island of New Zealand was not affected, and not a single spore formed on the 43 non-target grasses (including nassella tussock, oats, barley, rye grass, wheat, rice, bamboo and sweet corn) that were inoculated during safety-testing. The rust will hopefully prove to be a useful tool for the most serious Chilean needle grass infestations in Marlborough as well as North Canterbury. An additional isolate of the rust that can attack North Island plants is still being sought.

► Living roofs – reducing stormwater runoff

Although living green roofs are increasingly common overseas, adoption in New Zealand has been impeded by lack of local data on suitable materials and performance in New Zealand conditions. For the last four years, we have worked with University of Auckland's School of Engineering and Auckland Council to develop a resilient light-weight substrate based on locally available materials and which conforms to international standards. We tested over 45 native and non-native plants, and quantified the performance and maintenance needs of the roofs. Trial living roofs in Auckland retained a median of 82% of rainfall per rainfall event, and reduced peak flow by a median of 93%. Living roofs had a moderating affect on external roof and internal building temperatures, making them cooler in summer. Other benefits include increased biodiversity and pollination services.

Considerable effort has gone into disseminating findings to planners, stormwater engineers, architects, landscape architects, contractors, industry suppliers and home owners with the support of Auckland Council and Auckland Botanic Gardens. Increasing the number of installations across domestic, commercial, private and public applications is key to making green roofs the norm in New Zealand, and it is pleasing to see such widespread community support advocating their extensive use in the rebuild of Christchurch.



Partnerships

We fulfil our core purpose through the provision of research and transfer of technology and knowledge in partnership with key stakeholders comprising industry, central and local government and Māori.

Our Focus

- Extensive collaborative research partnerships with other leading science agencies in New Zealand and overseas
- Strong, long-term partnerships with key stakeholders and end-users from industry, government and Māori
- Connectivity of data and data users through informatics infrastructure and technology
- Practical advice, services and applications to facilitate rapid uptake
- Access to and reusability of data in our databases and collections
- Commercially viable, internationally recognised business units for branded services in advance of early-stage commercial partners

Our activities fall into four general categories:

- Collaborative research
- International networks
- Technology transfer and stakeholder engagement
- Branded commercial services and technology pipeline

Key Stakeholder Comment

Each year we commission an independent survey of our key stakeholders. This year, we were very pleased to receive the following comment from the survey researchers: *"This year's results show a marked improvement on previous years. This is mainly due to Landcare Research's proactive engagement in the CRI Taskforce reform process, greater collaboration and alignment with stakeholders at a strategic level and cooperation with other providers and end-users. There is a high level of trust in Landcare Research's work and stakeholders appreciate Landcare Research's honesty and shared values. Stakeholders also like Landcare Research's greater use of tailored newsletters and research summaries."*

Collaborative Research

Our focus on complex environmental issues across sectors and spatial scales complements the capabilities of the primary-sector CRIs (AgResearch, Scion and Plant & Food Research) that are principally focused on economic performance within their sectors. We collaborate with them on environmental issues of relevance to specific sectors (e.g. greenhouse gases in the dairy sector, and plant diseases in the kiwifruit sector). Similarly, we complement other CRIs and universities with an interest in the natural

Formal collaborative research centres and networks

We are formal partners in several collaborative research centres with universities, other CRIs and sectoral groups:

- The **New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC)** – 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, and all the CRIs www.nzclimatechangecentre.org
- The **Centre for Biodiversity and Biosecurity (CBB)** with the University of Auckland, including the Joint Graduate School www.cbb.org.nz
- The **Centre for Urban Ecosystem Sustainability (CUES)** with the University of Auckland
- 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 **National e-Science Infrastructure (NeSI)** high-performance supercomputers with the Government, Universities of Auckland, Canterbury and Otago, and NIWA www.nesi.org.nz

environment (NIWA and GNS Science, especially). We collaborate with NIWA on issues linking land use to water quality and quantity, and with GNS Science on long-term land erosion issues. Landcare Research plays a key role in leading geo-informatics and data management across the CRIs and universities, most recently through NeSI.

All of our larger sites are located on or close by university campuses to facilitate collaboration.

Formal research networks and consortia

We are members of:

- The **KiwiImage consortium**, a multi-agency, 5-year programme to acquire new higher resolution, multi-purpose satellite imagery for all of New Zealand and its subantarctic islands. www.kiwimage.govt.nz
- The **Regional Councils' Biodiversity Forum**, which decides regional priorities for biodiversity research.
- The **Sustainable Land Use Research Initiative (SLURI)** that pools soil science expertise across three CRIs to develop new tools for regulators and land managers (failure to sustain our soil and water resources will put \$2.16 billion of our total GDP at risk). www.sluri.org.nz
- **Integrated Research for Aquifer Protection (IRAP)** with four CRIs, DairyNZ, Lincoln Environmental, Aqualinc and Environment Canterbury. The focus is on developing agriculture and rural economies while ensuring water remains clean, available and contaminant-free. The end-user advisory group includes regional and district councils, MAF, MfE, FAR, HortNZ, Te Rūnanga o Ngāi Tahu, and Federated Farmers. www.irap.org.nz
- **NzOnet**, a network of nitrous oxide researchers from four CRIs, two universities and DairyNZ.
- **Methanet**, a framework of methane researchers from four CRIs, two universities and DairyNZ. www.methanet.org
- **CarbonNet**, a network of soil carbon researchers from five CRIs and three universities. www.carbonnet.co.nz

Highlights – International Research Collaboration

Landcare Research is very well connected to global counterparts in most parts of the world. Our goal is to use these connections to enhance our science and leverage benefits for New Zealand.

► China

Landcare Research has an ongoing collaboration with the Xinjiang Institute of Ecology and Geography (Chinese Academy of Science) at Urumqi, north-west China, and the Fukang Station of Desert Ecology in Xinjiang Province for research on (1) measuring and modelling carbon exchange for desert ecosystems, (2) the impacts of grazing management on carbon storage in vegetation and soil, and (3) various pest management issues. This year we also discussed collaborative opportunities with the Chinese Research Academy of Environmental Sciences (CRAES) in Beijing, and hosted colleagues from the China Agriculture University to discuss collaboration for an early-warning system for rodent outbreaks in agricultural areas of China. One of the three priority action areas under the New Zealand and China Environmental Cooperation Agreement is the Management of Invasive Alien Species and Biodiversity Protection.

► South America

Biocontrol of weeds: Biological control of weeds staff regularly work with counterparts in Argentina, Brazil, Chile and Colombia seeking potential biocontrol candidates for a range of weeds including Chilean needle grass, banana passionfruit, moth plant, pampas, Darwin's barberry and tradescantia, and providing advice on biocontrol for their weeds such as hieracium and gorse.

Forest dynamics and invasive species: This year, the Chilean Government's science agency, CONICYT, established a formal research collaboration between the Corporación Instituto de Ecología y Biodiversidad and Landcare Research. This will focus on ecological issues that are similar between Chile and New Zealand, including the dynamics of similar forests (e.g. *Nothofagus*), and the effects of invasive plants on ecosystems, again because many invaders (e.g. pines and Scotch broom) are common to both New Zealand and Chile.

Agricultural greenhouse gas emissions: CONICYT also funded an initiative to foster research collaboration on measurement and management of agricultural greenhouse gas emissions in Chilean soils under different land-use and land-management regimes. We are working with the Institute of Agro-industries at the Universidad de La Frontera and the Institute of Investigation in Agriculture (INIA) helping develop their research capacity and helping them develop several research projects.

Beaver eradication: Our Invasive Species International consultancy group has been working with the governments of Chile and Argentina and community groups on the feasibility of eradicating introduced North American beavers from Tierra del Fuego.

Poverty alleviation: We are a key partner in a 3-year NZ\$2 million project (with NZ\$600,000 from NZAID) to improve and sustain the livelihoods of poor inhabitants of the high Andes in Cotopaxi Province, Ecuador. Our technical assistance has included a water resource inventory to improve water allocation and management; vegetation mapping of the catchments to understand how quickly the natural land cover and stored carbon are being lost; advising on likely impacts of climate; land use change; and options such as payments for ecosystem services to assist indigenous communities with land use and water planning.

Pest management in the Galápagos Islands: Island Conservation, in partnership with the Galápagos National Park and Charles Darwin Foundation, is planning the progressive eradication of introduced rodents (*Rattus* spp. and mice) from islands in the Galápagos Archipelago. We were contracted by Island Conservation to assess the potential exposure of Galápagos tortoises, lava lizards, geckos and an endemic snake to the rodent toxin (brodifacoum) proposed for aerial application, and what the effects might be from ingesting it. The work is being used to refine non-target risk assessments and control strategies.

► Pacific Island countries

We support New Zealand's Official Development Assistance in Pacific Island countries by undertaking a range of science

collaborations with the regional University of the South Pacific (USP) and other Pacific organisations.

These have included integrated catchment management to reduce degradation of coastal coral reefs, curation and data management of biological reference collections, environmental domains, bio-indicators of stream quality, economics of invasive species, and carbon inventory and accounting including carbon-based revenue opportunities.

► Europe

Knowledge Based Bio-Economy (KBBE) Forum, Brussels

KBBE is major theme for EU funding with collaborative work streams on biomaterials, food for health, and aquaculture. We developed a new work stream on sustainable agriculture, to be led by New Zealand, which was accepted by the Forum. This will accelerate progress on challenges such as nutrient scarcity.

We hosted an international workshop on sustainable agriculture with delegates from New Zealand, Australia, Canada and the EU. The workshop identified a set of collaborative opportunities, and produced a communiqué for science, policy and industry organisations on the KBBE Sustainable Agriculture work stream to inform in-country research agendas and investment priorities.

► USA

We are working with the internationally regarded Computation Institute (a joint initiative between the University of Chicago and Argonne National Laboratory, both in Illinois, USA) to develop the MAF-funded Integrated Assessment Modelling project. Particular focus is on integrating economic and environmental modelling of forestry with pastoral and cropping agriculture in medium- or high-resolution spatial models. In future the model could be expanded to large countries/continents, and globally.

► Global

Global Research Alliance: The Alliance facilitates collaborative research on mitigating agricultural greenhouse gas emissions. About 30 countries have joined the Alliance,

which was initiated and championed by New Zealand. One of our science team leaders has been appointed as a New Zealand representative on the Soil Carbon and Nitrogen Cycling Cross Cutting Theme spanning the three focus areas: paddy rice, croplands and livestock.

The Global Soil Map: www.globalSoilMap.net

The Global Soil Map (GSM) will use 11 key soil attributes to create digital models at 90-m resolution and to 2-m depth – surprisingly detailed for global maps. The project is very challenging technically and is only now possible given recent advances in digital soil mapping techniques and the recent availability of spatial prediction layers, for example the global 90-m digital terrain model derived from the Shuttle radar mission. Our focus in the Oceania effort will be the areas for which we have significant datasets – the Pacific Islands, Antarctica, and of course New Zealand. The international science committee of the GSM noted that Landcare Research has provided the first example of a national planning methodology for operational mapping; it will become a part of the international methods manual.

Landcare Research also co-chairs the Cyber-Infrastructure Working Group within the project (with CIESIN, Earth Institute, Columbia University).

Biodiversity Informatics: Landcare Research is recognised internationally as an active centre of biodiversity informatics. We are members of the Biodiversity Information Standards (TDWG, www.tdwg.org), an international group developing information standards that underpin data-sharing networks like the Global Biodiversity Information Facility (GBIF). We are the New Zealand node for GBIF, mobilising 1.6 million biodiversity records from our Nationally Significant collections and databases. At the global level GBIF facilitates the sharing of 300 million records from over 12,000 datasets. www.gbif.org

We lead the New Zealand Organisms Register (NZOR, www.nzor.org.nz), a multi-agency, first-ever digital census catalogue of species. NZOR is a regional hub for Species2000, a global project supported through €5.9m EU projects 4D4Life & i4Life attempting to complete the global Catalogue of Life. We are a partner in 4D4Life and a member of the Species2000 global committee.

Highlights – Technology Transfer in New Zealand

Landcare Research works in partnership with central and local government, industry and Māori organisations. We engage in a wide range of initiatives that are focused on timely sharing of relevant information in accordance with end-user priorities.

▶ Regional Council Roadshow

Along with NIWA and other research providers, we participated in the Council Research Roadshow, organised by EnviroLink, that visited 15 regional councils and unitary authorities during the year. The Roadshow covered research we are doing for various councils as well as other projects and resources of relevance to local government responsibilities and operations. The presentations were well attended by regional council staff in all areas and provided an opportunity for scientists and council staff to discuss common interests. We are following up on topics raised.

▶ Biodiversity: 2010 and beyond

Landcare Research organised, and was principal sponsor for, *Biodiversity: 2010 and beyond*, the 2010 annual conference of the New Zealand Ecological Society. The theme of the conference recognised the United Nations International Year of Biodiversity. The conference attracted a record number of delegates, including biodiversity managers from central and local government, as well as university students and researchers. A series of symposia examined biodiversity in relation to human populations – cultural perspectives, production lands, and urban ecology, as well as traditional topics associated with reintroductions and predator control. The conference was able to facilitate the uptake of new science for policy, management, and academic researchers.

▶ Biosecurity Bonanza

Following the popular success of the first Biosecurity Bonanza in Christchurch in 2010, another was held this year in Auckland. The free, one-day workshops began as an initiative to make our science more accessible to our stakeholders and encourage more dialogue. This year's workshop highlighted research from four MSI programmes: Beating Environmental Weeds, Invasive Mammal Impacts on Biodiversity, Control of Small Mammal Pests, and

TB and Suppression Systems. After brief overviews of each programme, the nearly 100 attendees from 25 organisations could choose between concurrent sessions on weed and animal pest management. Sessions covered problems, perceptions and risks, ecology, management strategies and technological solutions. There was good audience participation, particularly on contentious issues such as the risks posed by anticoagulant residues in the environment and the balance between public perceptions and evidence-based decisions for pest control. As with the first workshop, feedback was extremely positive.

▶ Biocontrol of weeds training courses

Each year, we offer training courses for people who need to better understand or manage weed biocontrol programmes. The 2-day introductory course covers the underlying philosophy and current projects. Indoor sessions are interspersed with practical activities in the field. The advanced workshop focuses on new developments, and covers some topics in more depth. The workshops are free of charge although organisations that are part of the National Biocontrol Collective have priority.

▶ Interactive weed key

www.landcareresearch.co.nz/research/biosystematics/plants/weedskey

In March 2011, we published an online, interactive, illustrated identification key to all 328 species on DOC's Consolidated List of Environmental Weeds in New Zealand and the National Pest Plant Accord (NPPA) list of species banned from sale, distribution, and propagation in New Zealand. Other weeds are included in the key along with similar and related species.

▶ National Land Resources Centre

Over the last nine months we have worked with various stakeholders to scope the need for a national repository for land resource data and information, and establish a National Land Resource Centre. We envisage this highly significant repository will bring together data from fundamental research (from within Landcare Research and from other science providers) as well as data from a

number of government and industry stakeholders. Once these authoritative sources of information have been established (in both electronic and hard copy), eResearch innovations will be used to provide easy access across a range of scales to assist organisations in reporting on the state of the environment, planning development within environmental limits, and ultimately matching land use to the capacity of land resources.

► LRIS portal (Land Resource Information System)

<http://lris.scinfo.org.nz/>

The Land Resources Information System portal, launched in August 2010, provides users with ready access to 80 land and soils datasets. Of over 500 registered users, 28% are from New Zealand businesses; 80% of the 8500 visitors are from New Zealand, with significant numbers from Australia, USA, Sweden, India, Canada and Netherlands. The most popular data are the DEMs, the FSL Soil Classification, and the NZLRI Vegetation and Soil layers.

A survey of LRIS portal users found that 77% thought the portal was important to their business and 73% agreed it was important for their research; 62% agreed that making data available through the portal had created new possibilities for them; and 61% produced higher quality work. There is significant reuse and sharing of data: 72% reused the data they downloaded and 30% had shared the data with others in their organisation. Many respondents also reported they would like to see more of Landcare Research's data available through the portal.

► Precision irrigation workshop

A one-day workshop was hosted by Landcare Research to present our ongoing work on developing a suite of on-farm tools for precision irrigation, including the online S-map information system, paddock-scale mapping using electromagnetic sensors, wireless sensor networks for monitoring real-time soil moisture, and the use of *in situ* lysimeters for on-farm monitoring of soil drainage. Efficient use of soil moisture has huge potential to significantly improve performance in irrigation systems. It was also an opportunity to get feedback from attendees representing MAF, MfE, FRST, DairyNZ, SIDDC (South Island Dairy Development Centre), ECan, Otago Regional Council,



Auckland Council

Auckland Councillor Sandra Coney (L) and Auckland Council Biosecurity Manager Jack Crow (R) helping Chris Winks release tradescantia biocontrol agents.

Hawke's Bay Regional Council, IrrigationNZ, AgResearch, Plant & Food Research, New Zealand Centre for Precision Agriculture (Massey University), Central Plains Irrigation Scheme, Federated Farmers, Precision Irrigation, and two leading irrigation farmers.

► The Sustainable Business Forum at BusinessNZ

The Sustainable Business Forum (SBF) is an initiative of BusinessNZ as part of their Sustainable Business Programme. Member companies include the Bank of New Zealand, Contact Energy, Fonterra, Genesis, Landcare Research, Rio Tinto, Meridian, NZ Post, Solid Energy and Westpac. One of the projects SBF has been carrying out is the Sustainability Performance Benchmarking Project, which seeks to identify universally applicable key performance indicators (KPIs) for sustainability benchmarking. Landcare Research has supported and worked with SBF members to identify a set of core KPIs for their reporting. The finalised KPIs and measuring methodologies will be tailored to be relevant to New Zealand businesses, including small and medium-sized enterprises (SMEs), regardless of sector. In developing the KPIs, alignment with the GRI G3's performance indicators has also been sought so that companies can move to GRI reporting should they meet the other GRI requirements beyond performance indicators.

In an effort to encourage sustainability reporting in New Zealand, Landcare Research and BusinessNZ have entered an agreement with GRI to become the data partners for New Zealand. The role of data partners is to keep detailed records of and promote sustainability reports published by New Zealand companies.

Highlights – Branded Commercial Services

Landcare Research has continued to take a leading role in providing innovative solutions to business and industry via a range of dedicated branded businesses. Our goal is to add value to the New Zealand economy through commercially viable products and services, including transferring them to partners in the private sector and licensing to overseas partners where appropriate. Despite a tough trading year in the face of global economic caution, we are pleased with positive progress and overall growth.

▶ Sirtrack – wildlife tracking solutions

Sirtrack is a high-technology wildlife-tracking-solutions business with 88% of its revenue derived from overseas sales. A sluggish market and the high value of the New Zealand dollar led to a first-quarter loss. Sirtrack responded to the challenge by streamlining its manufacturing processes, and resizing and refocusing its operations. As a result, it returned profitable quarters for the rest of the year. The company continued its marketing push launching a new brand and transitioning to a full range of high quality 'standard' products to replace products that needed to be customised for each use and each client. This year, 31% of orders were met with 'standard' products; the target over the next three years is to meet 80% of orders with the standard range of products.

While we continue to use their products in our research, Sirtrack's business strategy has limited fit with Landcare Research's core purpose. Hence Sirtrack has put considerable effort into developing a tightly focused business that is investor ready for future sale.

www.sirtrack.com

▶ The carboNZero programme

The carboNZero^{Cert™} programme had a strong year with an impressive 29% increase on net revenue from last year. The business operates in four markets (New Zealand, Australia, UK and Chile) and signed a second licensing partner in Australia. The business maintained its ISO 14065 international accreditation through JAS-ANZ. Since its formation in 2001 and across all markets, the programme has issued 528 GHG certificates, verified 44.6

million tonnes of CO₂e (equivalent) emissions and offset 233,397 tonnes of CO₂e. (To help get this very significant achievement into proportion, the verified emissions are equivalent to more than 60% of New Zealand's total emissions for 2009, as announced in April 2011.)

Clients include Westpac, Toyota New Zealand, Flight Centre, Ricoh New Zealand and Villa Maria Estate. International clients include the Scottish Parliamentary Corporate Body, the UK's largest listed water company United Utilities, the Emirates Wolgan Valley Resort and Spa in Australia, Sleepmaker Australia and VINO Cono Sur Winery in Chile.

During the year, the carboNZero programme signed a licensing agreement with Lloyds Register Quality Assurance Ltd (LRQA) Australia, entitling LRQA to provide CEMARS[®] certification programme to clients in Australia. This is the second licensing agreement in the Australian market. LRQA operates primarily in the manufacturing, transport, energy and marine sectors. LRQA is a member of the Lloyd's Register Group and has a worldwide reputation for pioneering climate change services for its clients.

From 1 July 2011, the business commenced operating as a wholly owned subsidiary company, carboNZero Holdings Limited, with its own CEO and Board of Directors. With this independent positioning, the company is better placed to seek external investment and accelerate its international growth. www.carbonzero.co.nz

▶ The Enviro-Mark programme

Enviro-Mark[®] is a five-level environmental management and certification programme with independent auditing at each level. Despite tough trading conditions, membership grew by 8% last year, to more than 180 organisations.

A recent independent customer-survey showed most members belonged to the programme because of the importance of the environment to their company culture (rated by 75% of respondents), the market competitive edge it provides (61%), the desire to achieve costs savings (45%) and to respond to supply chain pressure (35%).



Members' overall satisfaction with the Enviro-Mark programme was high, with 83% rating the programme 7–10 on a 10-point scale. The helpfulness of Enviro-Mark staff achieved the same 83% rating. During the year the team supported programme participants with 31 training workshops, seminars, drop-in sessions and member networking events. www.enviro-mark.co.nz

► **EcoGene – wildlife DNA diagnostics**

The EcoGene® laboratory provides a range of wildlife DNA diagnostic services to New Zealand and Australian clients. The business has flourished with a 72% growth over the previous year. The strong growth was underpinned by a number of important research breakthroughs. EcoGene is now the key-provider of chytrid fungus screening in Australasia. In the last 12 months, they analysed c.1500 swabs as part of a programme to monitor prevalence of the disease in native frogs from New Zealand, Australia and Fiji. Another significant contribution was the pivotal role EcoGene played in helping MAF identify and develop their initial response to the disease outbreak in kiwifruit, and EcoGene undertakes ongoing PSA isolate testing.

EcoGene works with ESR, the New Zealand Wildlife Enforcement Group (WEG) and the New Zealand Centre for Conservation Medicine (NZCCM) to provide DNA forensic services to help thwart the illegal trade of endangered species at the border. This year EcoGene commenced a new contract identifying fish and shellfish species to help the Ministry of Fisheries monitor quotas and by-catch. www.ecogene.co.nz

► **EBEX21 – carbon farming**

EBEX21® facilitates land-use change, typically of marginal land, so that landowners can earn an income through the Permanent Forest Sink Initiative (PFSI) from credits

associated with naturally regenerating bush. PFSI leads the international arena for credible forestry-regeneration carbon credits. Retiring marginal land has other benefits for biodiversity, erosion control and moderating water runoff.

EBEX continued to work with a pilot group of property owners and MAF, with discussions focused on default sequestration rates and potential liability to participants who need to pay back excess credits at the time of field measurement. EBEX sold 4600 AAU Kyoto-compliant credits from three properties to carboNZero clients.

We also provided advice on potential carbon sequestration in regenerating forests through commercial contracts to a number of clients. www.ebex21.co.nz

► **Invasive Species International**

Invasive Species International (ISI) consultancy services leverage both New Zealand's and Landcare Research's world-leading reputations in pest management. During 2010/11, ISI contracted work for our staff in 18 projects and workshops in Australia, Fiji, Samoa, Juan Fernandez Islands, Galápagos Islands, Chile, China, Taiwan, Germany and the USA. ISI also hosted two events in New Zealand, a Pacific weed biocontrol workshop and a visit from a leading US expert on sustainable financial strategies for conservation.

Clients included various state and national agencies, NGOs, and research organisations, with projects covering the feasibility of proposed invasive species eradication programmes, progress reviews for eradication projects, strategies for reducing the risk of eradication attempts failing, improved methods for monitoring and detecting invasive species, and research on invasive species biology and impacts (particularly in relation to climate change) and new control tools and strategies. www.isinz.com

Awards

► Meritorious awards & appointments

Andrea Byrom: Chinese Academy of Sciences Visiting Professorship for senior international scientists with the Northwest Plateau Institute of Biology, Xining, People's Republic of China

Sam Carrick: 2010 Morice Fields Award from the New Zealand Society of Soil Science in recognition of the exceptional merit of his PhD thesis

Dave Choquenot, Bill Lee and Roger Pech: Professorial appointments to the joint graduate school with University of Auckland. The school will focus on biodiversity and biosecurity projects aligned with our Core Purpose.

Thomas Buckley and Dianne Gleeson: Associate Professorial appointments

Simon Fowler: Fellow of the Royal Entomological Society (London)

David Galloway: Hutton Medal – for excellence in plant sciences, awarded by the Royal Society of New Zealand for his significant contribution to the understanding of the New Zealand environment through great advances in knowledge of New Zealand's richly diverse lichens

Dianne Gleeson: 'Women in science entrepreneur award' from Pacific Channel, a venture capital and seed funding organisation, for her work in developing EcoGene's DNA-based analytical services that include detecting new organisms, monitoring pest species, disease monitoring and threatened species management

Gwen-Aelle Grelet: 50,000th Marie Curie Fellow and New Zealand symbolic representative at a 2-day high-level conference in Brussels, held by the European Commission and the European Research Executive Agency, to celebrate the launch of the programme in 1996. The conference was attended by President of the European Commission and President of the European Parliament

Aaron Hicks: 'KAREN Champion' for his consistently strong, positive and well-regarded contribution to the Kiwi Advanced Research & Education Network (KAREN)

Chris Phillips: Honorary Member of the New Zealand Association of Resource Management (NZARM), for 20 years' service to the association, promoting the aims and philosophies of NZARM

Daniel Than: QEII Technician's Study Award to collaborate with overseas' organisations on molecular-based assays to rapidly detect kauri die-back disease, and to develop skills in non-target host testing of rust fungi and quarantine facilities

The Central Otago Ecological Trust (COET): Inland Otago Conservation Award for their efforts to save Otago skinks from extinction. Landcare Research is a key partner and trustee in COET, and **Grant Norbury** is the Chair

► Travel awards

Peter Bellingham: a two-month fellowship from the Japan Society for the Promotion of Science (JSPS) to work at Tohoku University in Sendai and in the subtropical Ogasawara Islands to develop in-kind approaches to the study of invasive plants

Phil Cowan: International Mobility Funding to collaborate on vertebrate pest management with colleagues in Germany

Ian Dickie and Nina Koele: International Mobility Funding to bring a Belgian colleague here to study soil processes under kauri, and develop other collaborative projects

Shaun Forgie: International Mobility Funding for an evolutionary study of a group of beetles at the University of Western Kentucky

Ronny Groenteman: IOBC-Asia-Pacific Regional Section Young Scientist Award to attend the 3rd Combined Australian and New Zealand Entomological Societies Conference. Also a Council of Australasian Weed Societies Early Career Weed Scientist Travel Grant

John Hunt: Royal Society of New Zealand NZ-Germany ISAT award to work with colleagues on the effects of land-use change on carbon storage

Kevin Richards: International Mobility Funding to work with colleagues in the Netherlands on a Compositae taxonomy framework

Alan Saunders: International Mobility Funding to bring the Executive Director of Advanced Conservation Strategies (ACS) here on a 10-day visit to collaborate with pest management researchers, restoration ecologists, resource economists and carbon sequestration specialists

Darren Ward: International Mobility Funding to bring a colleague from Canada here for collaborative work on identification of parasitoid wasps

Susan Wisser: NZ-Spain S&T award to bring a colleague from the University of Barcelona to work here for 10 weeks

Professional Networks

- 48 staff (including research associates) hold 59 positions in professional societies (14 Fellows)
- 59 staff hold 133 positions on national and international advisory boards, technical groups and review panels
- 46 of our senior scientists (including research associates) hold 96 positions on the editorial boards of scientific journals
- 11 staff hold 17 directorships or board memberships
- 11 staff were invited to give keynote or plenary addresses at significant national and international conferences, with costs fully or partly covered
- 19 postdoctoral researchers were hosted, 5 of whom commenced during the year

Photos credits (from top to bottom):

RSNZ, Adrienne Farr, European Commission, Simon Baker, Dale Norbury

David Galloway (R)



Dianne Gleeson



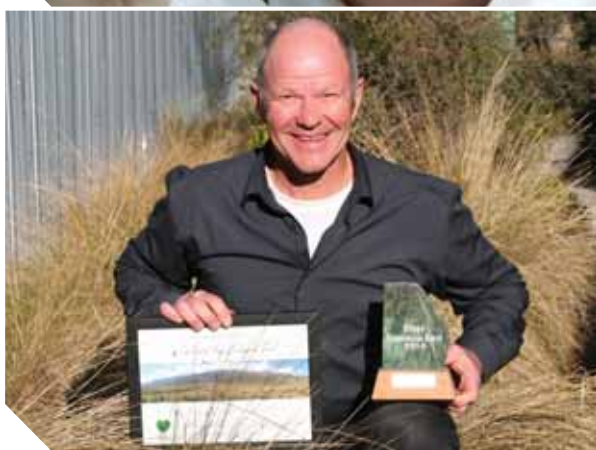
Gwen-Aelle Grelet (R)



Daniel Than



Grant Norbury





OUR ORGANISATION

Certifications & Partnerships

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► 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
- External (Telarc) verification that our carbon-neutrality meets the requirements of the carboNZero^{Cert}™ programme across all our sites, including Sirtrack at Havelock North

► We are members of:

- The EEO Trust
- The New Zealand Business Council for Sustainable Development (NZBCSD)
- BusinessNZ and the Sustainable Business Forum
- Sustainable Business Network
- New Zealand Green Building Council

► We are supporters of:

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

Canterbury Earthquakes

Canterbury suffered three major, damaging earthquakes in September 2010, February and June 2011, as well as continuing aftershocks. These earthquakes interrupted work directly and have caused much tiredness and stress. Virtually all of our Lincoln staff (about half the organisation) have been affected in some way but they continue to be resilient and as dedicated to their work as always. The care and support demonstrated by staff across all our locations has been impressive and heart-warming – manaaki tangata in its truest sense. We continue to provide ongoing support for staff with damaged homes and disrupted lives.

One of our staff is a qualified member of the Urban Search and Rescue teams that worked so hard immediately following all the damaging quakes. Other staff helped through their Fire Service and Civil Defence roles. Many staff helped the Red Cross and other emergency relief groups, or simply shovelled silt and cleaned up houses. We are proud of our staff!

Our buildings stood up well, suffering relatively minor damage, and our ICT systems were kept functioning ensuring minimal physical disruption. We have been able to accommodate some staff from our partner organisations whose premises could not be occupied.

Our People

▶ Human capital development

Our leadership development programme has been designed to deliver appropriately customised learning modules to different groups of leaders across the organisation. The third and final cohort will complete the programme in December. Each year we have modified the programme in response to feedback from the previous cohort, and each year the feedback has been exceptionally positive regarding personal/professional development, relevance and interest, and meeting participants' expectations.

We also introduced a \$5,000 study grant to provide specialist development opportunities for technicians. Two technicians benefitted from external training that otherwise would have been unavailable.

▶ Joint graduate school with University of Auckland

Landcare Research has formed a joint graduate school with the University of Auckland to produce postgraduate students in biodiversity and biosecurity sciences. Five Landcare Research staff have been appointed: three as professors and two as associate professors. The school will greatly enhance the number of postgraduate-qualified and 'job-ready' students entering the market – something that has been warmly welcomed by the government science and policy agencies responsible for biodiversity and biosecurity outcomes in New Zealand.

▶ First Foundation Scholarship Programme

In October 2010, we selected a promising final-year secondary school student to work with us under the First Foundation Scholarship Programme. This targets talented students in lower-decile secondary schools nationally. The scholarship will continue through to the end of the student's first three years at university.

▶ Remuneration strategy

We are reviewing our remuneration strategy in a three-stage project. The first stage worked with staff focus groups; the second used consistent methodology across

the organisation to size and evaluate science and support roles, and identify any trends or issues relevant to the remuneration strategy; and the third stage will involve working with the PSA to agree on policies and the wider remuneration strategy.

This year, science staff contributed to a band factor assessment process to review their current position; this led to a small number of important changes. We also introduced two new policies, on the cashing up of annual leave and trial periods.

▶ Collective Employment Agreement (CEA)

The CEA applies to members of the PSA, the union acting on behalf of 45% of staff. The agreement is in its third and final term expiring at the end of April 2012. The remaining employees are on Individual Employment Agreements, which fundamentally mirror the CEA. Only managerial staff (tiers one to three) have separate Total Remuneration Individual Employment Agreements.

▶ Staff engagement

This year we selected John Robertson Associates (JRA) to survey staff engagement, as JRA enables benchmarking with other CRIs and JRA's Best Workplaces in New Zealand. With 71.5% of staff participating, overall engagement was higher than the CRI benchmark but below that for Best Workplaces. Staff were very positive in their perceptions of our Health and Safety (H&S) and sustainability practices, the flexible work environment, and the alignment of our 'manaaki tangata' and organisational values. Areas for improvement include a greater sense of common purpose, and stronger focus on both leadership, and on learning and development across the organisation.

▶ Key performance indicators (KPIs)

We report on a wide range of good employer KPIs, including gender balance, pay equity, H&S, turnover and recruitment, ethnicity, training and knowledge management. A selection of KPIs are summarised on page 48, with comprehensive reporting and data on our sustainability web pages. www.landcareresearch.co.nz/sustainability

Infrastructure & Procurement

► New greenhouse gas research facility

A major strategic reinvestment project is the new greenhouse gas research facility being built at Lincoln, with completion due in November 2011. It will support our world-class research, attract visiting scientists from overseas, and underpin our partnership in the New Zealand Agricultural Greenhouse Gas Research Centre and Global Research Alliance. Staff were heavily involved in the design, particularly in optimising space for controlled environment cabinets; isolated areas for measuring, sorting, drying and grinding plant and soil material; and significant new field instrumentation for long-term measurement of greenhouse gas exchange and water use. The building features natural light, energy efficient fittings, insulation, and water reticulation/recycling systems. Our in-house project manager is Green Star Accredited and, although there is no Green Star rating available for a building of this type, the principles were applied throughout the planning and construction, including building-waste management.

► Building refurbishments

We continued to use sustainable products and materials, such as InterfaceFlor ReEntry carpet tiles made of recycled and recyclable materials, and less volatile adhesives in our ongoing programme of office and building refurbishments. Enviro-paints were used in repainting the exteriors of Palmerston North and Lincoln buildings.

► ICT to support our science

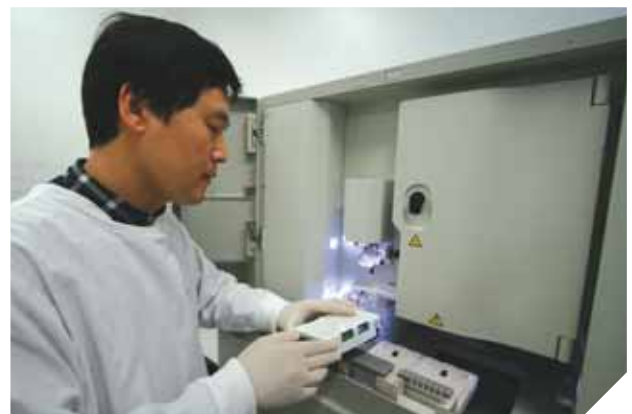
Our Information and Communication Technology (ICT) strategy is aligned to government expectations for creating new transformative value from data, collaborative research, disseminating research, and ease-of-access to our databases and collections. It also aims to improve workforce productivity, attract new talent, and share services and procurement initiatives across CRIs to reduce costs. A key goal is providing our mobile workforce with seamless 'anywhere-anytime' access to all science data and analytical processes, as well as to the company's operational systems. This year, we extended our internal Wifi network, evaluated new technologies, and began work on 'single search' functionality across our physical and electronic library resources. Staff use Yammer to casually

share information, links and ideas with other Landcare Research colleagues. We also used Yammer for some rapid-fire facilitated sessions enabling all staff across all sites to contribute to developing Landcare Research's vision statement.

We worked with the University of Auckland to establish the Tuakiri New Zealand Access Federation, which simplifies staff access to shared high performance computing resources. Our staff were able to access satellite 'images' and process huge data files of Canterbury immediately after the earthquakes.

► Procurement

The CRIs collaborate through the CRI Procurement Forum, leveraging off the combined spend to broker excellent supply deals delivering cost and service benefits, and improving sustainability of the supply chain. Our collective insurance contract resulted in significant cost savings for CRIs. In 2012 a hazardous waste contract will be negotiated by the forum to improve our collective capability in measuring, monitoring and managing this important waste stream. Syndicated and government supply contracts have led to further savings and service/supply improvements. We renegotiated lower rates for our mobile and voice communications, and took advantage of the All-of-Government (AoG) procurement initiatives in new contracts for desktop computing and multi-function printing-copying devices that meet our sustainability standards. We similarly used AoG rates to secure contracts for our field vehicles.



Duckchul Park using the Ecological Genetics Laboratory's advanced genome sequencer

Tom Fraser

Our Environmental Performance

▶ Greenhouse gas emissions

We reduced our greenhouse gas emissions for the second year in succession, despite an increased 'capture' of emission sources to meet best practice as recommended by the carboNZero^{Cert}™ audit last year. We now include emissions associated with hotel and motel accommodation nights, compostable waste to landfill, and embodied emissions in new buildings.

Landcare Research uses extensive specialist climate-conditioned vaults, fridges and freezers in the course of its science. In 2009/10, refrigerant leaks accounted for 16% of our total emissions. We invested in additional monitoring, maintenance, and some equipment replacement – this has paid dividends with no significant refrigerant losses experienced this year.

▶ Energy management

Energy consumption was down 8% compared with last year. We are making steady progress towards our target of reducing energy consumption by 15% over three years (our commitment to the Energy Efficiency Conservation Authority – EECA). Such good progress is largely due to our investment in energy-measuring equipment, and monitoring and managing energy use.

▶ Carbon neutrality

Telarc, approved verifiers to the carboNZero programme, reviewed our systems and records to verify that our carbon neutrality claims again meet carboNZero certification standards across all sites, including Sirtrack.

Our main energy provider, Meridian, can no longer guarantee that our electricity comes from renewable sources. Hence we had to purchase more carbon credits than last year despite a reduced greenhouse gas footprint (166 tonnes CO₂e less than last year). We bought a total of

2800 carbon credits (Beijing 48 MW Guanting Wind Power Project) through the carboNZero programme (2640 for Landcare Research, 160 for Sirtrack) to offset emissions for the year and achieve net annual emission-neutrality.

▶ Accidental by-catch of native animals

Three endemic bird species and 22 individuals were recorded as by-catch in routine field studies involving pest trapping. Unfortunately 19 were South Island robins, and they were all killed, mostly in snap traps set to kill rats. The traps had been placed in tunnels with the entrance restricted by sticks, but robins are naturally very inquisitive and tame. Robins are locally very common in the area, and the trapping has had little or no impact on their numbers. However, in future, we will endeavour to avoid methods that catch endemic species.

▶ Key performance indicators (KPIs)

We report on a wide range of environmental KPIs including materials use and recycling, energy, travel, emissions and offsets, water and wastewater, solid waste, and biodiversity impacts. A selection of KPIs are summarised on page 49, with comprehensive reporting and data on our sustainability web pages. www.landcareresearch.co.nz/sustainability

Compliance

Our operations are subject to a broad range of legislation covering environmental, good employer, human rights, ethical and financial issues. There were no material instances of non-compliance in 2010/11.

Financial Performance Summary

The accounts (for Parent and Consolidated Group) and Audit Report are in Part II of our Annual Report and also available in full on our website. Part I and Part II together constitute our statutory annual reporting responsibilities.

www.landcareresearch.co.nz/publications

SUMMARY TABLE OF FINANCIAL PERFORMANCE INDICATORS

	2009	2010 ¹	2011	2011	2012
	Achieved	Achieved	Target	Achieved	Target
Revenue, \$m	60.25	61.66	64.29	63.44	65.91
Net revenue, \$m	53.13	54.82	57.57	56.69	59.13
EBIT, \$m	2.36	2.19	3.05	2.93	2.10
EBIT margin	3.9%	3.6%	4.7%	4.6%	3.2%
Total assets, \$m	48.35	50.31	49.24	50.91	52.87
Return on equity	5.3%	6.4%	7.0%	8.4%	5.4% ²
Dividend, \$m	0.1	0.5	0.7	0.7	1.1
Equity ratio	58%	58%	61%	53%	52%
Gearing ³	13%	0%	0%	0%	6%
Interest cover	7.2	11.1	10.2	13.2	9.0

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

² The 2012 target is lower because we plan significant reinvestment in the organisation.

³ 2009 gearing is calculated on gross debt. For 2010 onwards, gearing is calculated based on net debt.

► Revenue:

Includes science research, 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 interest on investments and from finance leases, \$0.3m for 2011.

► EBIT:

Earnings before interest and tax, and after committed business development expenditure and commercialisation expenditure. It excludes restructuring costs.

► 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 = net financial debt ÷ financial 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.)

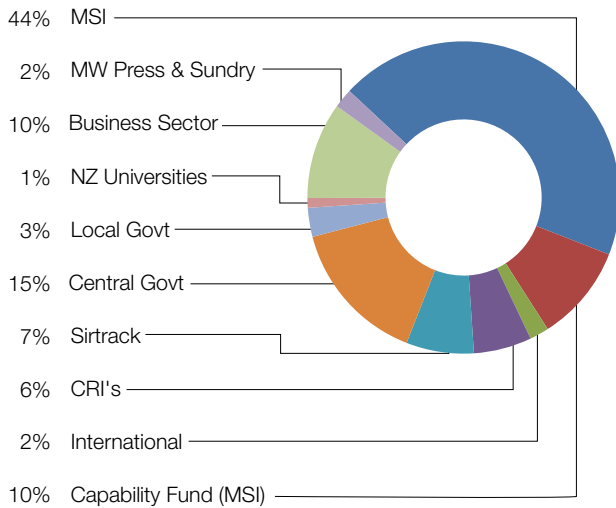
► Interest cover:

Interest is the cost of debt and financial leases. Interest cover = EBIT ÷ interest.

8.4%

return on equity
exceeded our target

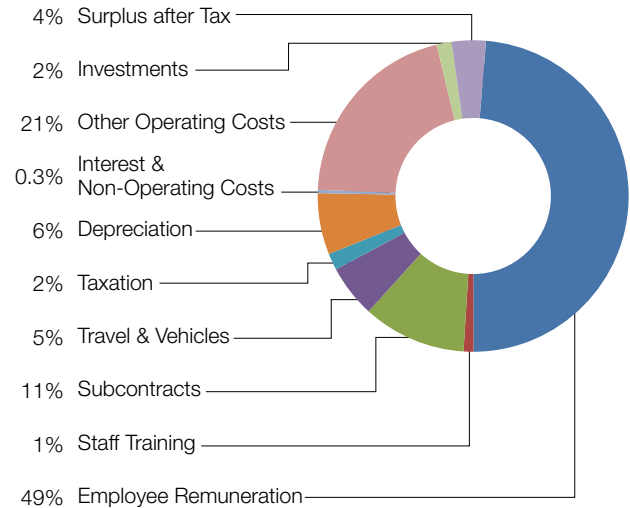
Where our revenue comes from



► Where our revenue comes from

- Ministry of Science and Innovation (MSI) 44% – contestably funded research programmes, negotiated funding and long-term OBIs
- MW Press & sundry 2% – Manaaki Whenua Press is our natural history and science book publishing and retailing business centre
- Private & business sector 10% – principally contracted work for businesses and private 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 MAF
- Sirtrack 7% – wholly owned subsidiary, which develops and produces telemetry equipment for tracking wildlife
- CRIs 6% – research subcontracted to us in collaborative programmes
- International 2% – development projects funded by donor agencies, international consultancy projects
- Capability Fund (MSI) 10% – funding used to maintain existing skills and to develop new science and technology capability

Where our revenue goes



► Where our revenue goes

- Investment 2% – support for technologies and services including those advancing through our commercialisation pipeline
- Other operating costs 21% – includes electricity, carbon credits, software licences, insurance, consumables, and lease costs
- Interest & non-operating costs 0.3%
- Depreciation 6% – includes accounting depreciation on buildings, science equipment and computers
- Travel & vehicles 5% – 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 11% – research subcontracted to other research providers, including CRIs and universities in collaborative research programmes
- Staff training 1% – includes conferences, training courses and support for postgraduate study (2.2% of the total payroll)
- Employee remuneration 49% – includes staff in management, science, support roles, commercial business and Sirtrack



OUR SUSTAINABILITY PERFORMANCE

Our Approach

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Our approach to sustainability (corporate social responsibility or CSR) goes beyond the focus on science for sustainable national outcomes to how we do business, how we engage with our staff and external stakeholders, and how we add value to society and the natural environment.

Our Sustainability Policy, Guiding Philosophy and Code of Ethics Policy apply to all staff, senior executive managers and directors. Our compliance management systems are strongly focused on best practice and continually monitoring and improving performance. We have maintained ISO 14001 environmental certification for many years; similarly our tertiary level (highest) rating for Workplace Safety Management Practices. We also

seek to assess and proactively manage future risk from (for example) environmental legislation, climate change, increasingly competitive global markets for talented staff, and issues that could damage our integrity and reputation.

This report presents key highlights that illustrate the breadth and impacts of our research, stakeholder engagement, business development initiatives, and operational activities. We provide considerably more sustainability performance information and KPI detail on our web pages, including invited 'thinkpieces', the role of mātauranga Māori in sustainability frameworks, and a wealth of connections to our research.

www.landcareresearch.co.nz/sustainability

On the Web

Voices for sustainability

- External perspective comments
- Role of Māori in sustainable development

Our sustainability aims

- Statement from the Chief Executive
- Business & science strategy
- Our stakeholders
- Our commitment to external initiatives

Our progress in 2010/11

- Our economic impacts
- Our climate change impacts
- Our environmental impacts
- Our people
- Our communities
- Scope of our reporting

Science for sustainability

- Our science outcome areas
- Alignment to national priorities
- Developing our science
- Environmental technologies & services
- Impact & integrity of our research

Materiality & Engagement

We use the Global Reporting Initiative (GRI)'s framework to guide our reporting and report in detail against the G3 guidelines plus additional indicators that are material to our government owners and our own operations. We believe our online sustainability reporting meets the requirements of Level A in the GRI's G3 framework. www.globalreporting.org

We endeavour to report all topical and significant aspects of our activities in a balanced, transparent manner, and meet the expectations of our government owners and other key stakeholders. Our work with the Business NZ – Sustainable Business Forum is outlined on page 31. We are also members of the New Zealand Business Council

for Sustainable Development and the Sustainable Business Network. Engagement processes with our key stakeholder partners and their priorities, as aligned to our science outcomes and impacts, are outlined in our Statement of Corporate Intent 2011–16.

<http://www.landcareresearch.co.nz/about/documents/sci1116.pdf>

Our performance and reporting are reviewed by our government owners, expert panels, our clients (via meetings, contract discussions and the external annual client survey), and by staff who work closely with the Sustainable Business Forum members of Business NZ and as GRI data partners.

Summary of Non-Financial KPIs

I. STAKEHOLDER RELATIONSHIPS

We strive to build strong relationships with our clients and stakeholders.

Stakeholder relationships	2008 Actual	2009 Actual	2010 Actual	2011 Target	2011 Actual
Invited technical expertise – total comprising:	229	311	234	>220	281
<i>Staff invited to participate in stakeholder meetings or workshops in New Zealand & overseas ¹</i>	191	251	193	-	252
<i>Landcare Research staff invited on to national advisory panels, groups & boards ²</i>	38	41	41	-	38
Partnership initiatives – total comprising:	365	390	365	>350	399
<i>MOUs</i>	16	12	16	-	10
<i>Collaborative proposals (excl. with other providers) ³</i>	141	185	158	-	195
<i>New R&D proposals for Māori groups</i>	-	4	6	5	2
<i>Client staff on Landcare Research advisory groups ⁴</i>	86	87	60	-	69
<i>Staff secondments – to other agencies</i>	3	4	3	-	3
<i>– from other agencies</i>	1	1	1	-	1
<i>Other agency staff co-located with us</i>	85	101	100	-	110
<i>Our staff co-located with others</i>	14	7	7	-	9
Revenue from public- & private-sector clients (excl. FRST, MoRST, MSI, universities & other CRIs)	\$15.1m	\$18.8m	\$17.2m	-	\$18.3m

¹ Includes invitations to participate in overseas groups, meetings and workshops. Excludes the carboNZero and Enviro-Mark NZ programmes.

² 38 of our staff were invited to 66 advisory positions.

³ The focus is on stakeholders with whom we collaborate. Hence we count the number of collaborators in each programme or project.

⁴ Includes OBI Governance groups.

II. LINKS WITH UNIVERSITIES

All our major sites are located on or close by university campuses to facilitate collaboration.

Links with universities	2008 Actual	2009 Actual	2010 Actual	2011 Target	2011 Actual
NZ university staff in our research programmes	54	51	48	-	38 ¹
Our staff in university programmes	12	25	18	-	13 ²
Postgraduates being supervised by our staff	94	98	98	-	71 ³
Staff paid to lecture in university programmes	9	12	14	-	12 ⁴
Honorary university positions	44	38	41	-	36
Māori scholarships	-	1	1	2	0

¹ 38 staff from 7 universities in 26 of our programmes.

² 13 staff in 15 programmes at 5 universities.

³ 47 PhD, 21 MSc and 3 postgraduate diplomas.

⁴ 12 staff delivered 20 sets of paid lectures; another 17 staff delivered 23 sets of lectures without payment. Another 6 staff hold joint professorial roles with universities.

III. SOCIAL & COMMUNITY ACTIVITIES

Staff often participate in a wide range of initiatives (e.g. presentations to schools and interest groups) that are generally outside contracted outputs in research programmes. Some staff also voluntarily contribute roles within civil defence, search and rescue, and fire brigades. Many of our Lincoln staff also helped in communities affected by the Canterbury earthquakes. Community activities usually involve additional personal time and commitment, hence are significantly under-reported.

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We use Facebook and Twitter to draw attention to interesting research, and we posted 35 video clips on our YouTube channel. The number of followers is gaining momentum, with a pronounced upswing in the number of community conservation groups 'liking' and 'following' us.

Social & community activities	2008 Actual	2009 Actual	2010 Actual	2011 Target	2011 Actual
NZ university staff in our research programmes	NA	51	110	100	135 ¹

NA = not available ¹ Excludes media coverage, social media and supervision of university students or lecturing.

IV. ENVIRONMENTAL TECHNOLOGIES & SERVICES

We add value to the economy through developing new products and services, including transferring or licensing them to partners in the private sector. At the end of the year, our technology pipeline included 8 items at the prototype stage (1 with patent protection), 11 under development, and 6 undergoing commercial testing (1 with patent protection).

Research application	2008 Actual	2009 Actual	2010 Actual	2011 Target	2011 Actual
New or improved products, processes & services ¹	81	73	70	60	30
Patents granted – in NZ	0	1	1	2	1
– overseas	0	0	0	1	0
Licensing arrangements	2	3	2	3	2
Joint ventures	0	0	1	1	1
Spin-off companies formed	0	0	0	1	1 ²

¹ Excludes contract reports, peer-review roles or ongoing advisory positions; includes new web products and processes. This year, the new Land Resource Information Services Portal and NZ Virtual Herbarium count as single products but each provide multiple services for multiple users.

² The carboNZero programme became a wholly-owned subsidiary on 1 July 2011.

V. USE OF NATIONALLY SIGNIFICANT DATABASES & COLLECTIONS

Landcare Research is custodian of seven of the recognised 'Nationally Significant Databases and Collections for New Zealand'. These cover biological resources (species and ecosystems), soil and land resources, and cultural knowledge. They are used extensively in research and to underpin New Zealand's biosecurity, biodiversity, export/import trade, land management, and publications of ecological and biosystematics interest. We are committed to increasing the value of these national assets to benefit both the public and private sectors. Some achievements for the year follow.

LRIS portal: The new portal access launched this year has facilitated access to our land resource databases. The portal is well used and well received (page 31). The LRIS portal metadata can now be searched or harvested by third-party clients who support the OGC Catalogue Services for the Web (OGC CSW) service specification. The OGC Catalogue Services specification establishes a general framework for access to metadata through web services. Using the OGC CSW service, the New Zealand Geospatial Office has been able to harvest our records for presentation in their new Catalogue of Environmental & Geospatial Data.

The new LRIS web service has also been registered with the Global Earth Observation System of Systems (GEOSS) Component and Service Registry Publication Portal, and Landcare Research's geospatial data are now discoverable through the international GEO Portal.
<http://www.geowebportal.org>

Fieldbook Tool – Collection Information System: The field book is a software tool that allows researchers across New Zealand to compile data about newly collected specimens while in the field. Once material has been processed and data correctly compiled, an automated import process inserts the data directly into the main Landcare Research Collection Information System. The new fieldbook tool improves and streamlines data compilation practices, data quality, and data handling and integration into our Nationally Significant biological reference collections.

NVS joins the Global Index of Vegetation-Plot Databases (GIVD): The NVS Databank is one of 131 vegetation-plot databases currently registered in GIVD, and with records from 77,000 independent plots, NVS represents the 6th largest registered vegetation-plot database in the world. GIVD is a global metadatabase of publicly available vegetation data that was established last year following the

9th International Meeting on Vegetation Databases, held in Germany. (As a metadatabase, it contains data about and links to these vegetation-plot databases, but not the data themselves.) We are also a member of the Steering Committee for GIVD. www.givd.info

Launch of NZ Virtual Herbarium: The New Zealand National Herbarium Network launched the New Zealand Virtual Herbarium (NZVH), a collaborative network project hosted by Landcare Research that aims to provide online access to the information managed by herbaria in New Zealand. This phase of the NZVH is being implemented using software developed for the Australian Virtual Herbarium and made available by the Council of Heads of Australasian Herbaria. www.virtualherbarium.org.nz

An electronic Flora for New Zealand: During the year, we worked with Te Papa and NIWA on two pilot projects to test plans and guidelines for electronic Flora (e-Flora). The e-Flora covers the New Zealand botanical region; it will include naturalised as well as indigenous plants. The first stage was publicly available in mid-December 2010.

A continually updated e-Flora incorporating new botanical research as well as a large network of databases and online resources will assist biosecurity and conservation managers to better identify, study and manage plants throughout New Zealand and overseas.

Biodiversity catalogue of hoppers and cicadas known to occur in New Zealand: Six years of intensive research on leafhoppers, cicadas, spittlebugs, treehoppers, and plant hoppers led to the completion of the first ever comprehensive inventory for this group. These economically important insects account for a greater number of major plant pests and disease vectors on a world basis than more diversified insect orders (e.g. beetles). In New Zealand 82% of species are endemic. www.landcareresearch.co.nz/research/biosystematics/invertebrates/hemiptera/cicada



Amphisalta zelandica

The results are presented as a comprehensive biodiversity inventory to meet the needs of researchers, biosecurity and conservation managers, and the general public.

Image galleries and online guides: Stunning image galleries and online guides for weevils and large moths and butterflies allow anyone to identify specimens they encounter. New Zealand has about 1500 described species of weevils, about 1650 species of moths but only 24 butterfly species.

<http://largemoths.landcareresearch.co.nz>

<http://weevils.landcareresearch.co.nz>

Fauna of New Zealand series: Two new volumes were published this year. Fully searchable PDFs of 66 volumes are available at <http://fnz.landcareresearch.co.nz>. While intended for quite a specialised audience, each volume includes a popular summary in both English and Māori.

Visitors and public services: Our nationally significant biological collections host numerous visitors, including public interest groups. Identification services are provided to the general public as well as to stakeholder agencies. For example, the Allan Herbarium hosted 244 visitors in 2010/11 and identified 1000 plants; the New Zealand Arthropod Collection answered 296 public enquiries.

Requests for datasets & specimens	2008 Actual	2009 Actual	2010 Actual	2011 Target	2011 Actual
Total datasets & specimens provided (excludes web page views)	>12,300	>20,700	>13,400	>15,000	>12,700
Land Resource Information Systems (LRIS): datasets delivered ¹	21	12	28	-	>1,500 ¹
<i>Visits to the LRIS portal</i>	-	15,700	18,258	-	>8,500 ²
National Vegetation Survey Databank (NVS): datasets supplied ^{1,3}	1,605	1,768	3,978	-	1,243 ^{1,3}
NZ Arthropod Collection (NZAC ; includes NZ National Nematode Collection): specimens loaned or supplied ^{3,4}	c. 5,000	15,000	7,000	-	7,500 ^{3,4}
International Collection of Microorganisms from Plants (ICMP): cultures supplied	522	740	721	-	884 ³
NZ Fungal Herbarium (PDD): specimens loaned or supplied ³	155	282	168	-	452 ³
<i>Associated databases (ICMP & PDD): number of page views</i>	>360,000	>256,600	>237,900	-	>252,500
Allan Herbarium (CHR): specimens loaned or supplied ³	4,988	2,903	1,552	-	1,087 ³
<i>Associated databases (CHR): number of page views</i>	619 June only	>191,400	>174,800	-	>198,900
<i>Ngā Tipu Whakaoranga Ethnobotany Database: number of page views</i>	>15,400	>17,400	41,240	-	>37,370
NZ Flax and living plant collections: collections supplied	27	29	34		38

¹ Data can be used for multiple purposes.

² Over 10 months. Visitors can access data from the National Soils Database (NSD) and NZ Land Resource Inventory (NZLRI) in one visit. Previous years' data are for page views in the NSD and NZLRI

³ Outward only; excludes incoming loans, exchanges or additions to the collections.

⁴ The number of specimens in each vial varies between 1 and more than 50 depending on size of organisms.

VI. PUBLICATIONS & PRESENTATIONS

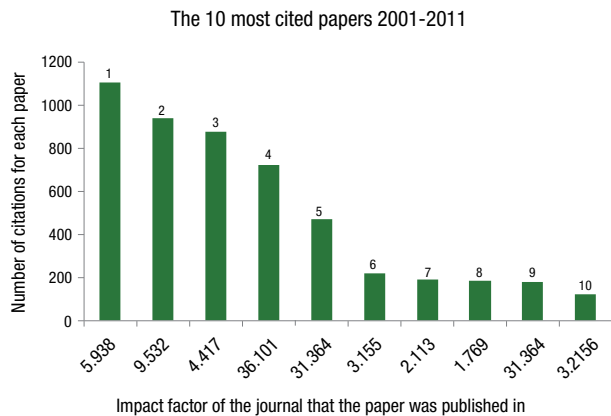
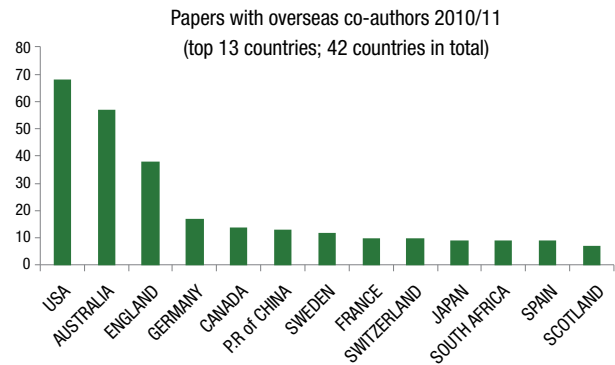
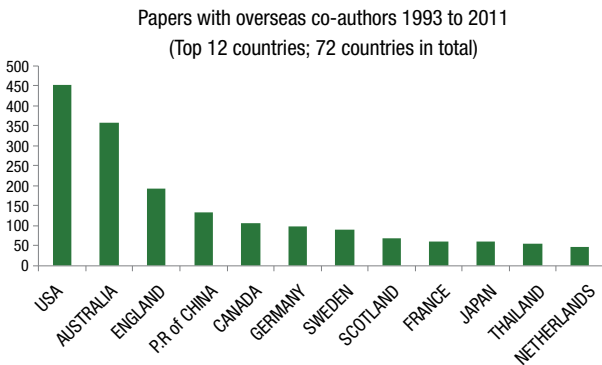
Landcare Research focuses on excellent scientific research and its effective application in policy and practice.

Publications & presentations	2008 Actual	2009 Actual	2010 Actual	2011 Target	2011 Actual
Commissioned reports on research issues & results	200	177	185	190	223
Contracted reports to clients in Enviro-Mark & carboNZero programmes	NA	42	22	-	24
Presentations (Total)	538	487	417	450	596
- Conference	192	232	169	-	287
- Science presentations to stakeholders & community groups	279	205	220	-	271
- Presentations from Enviro-Mark & carboNZero programmes	67	50	28	-	38
Publications on technical information & research results ¹	165	181	349	250	374
Papers published in peer-reviewed journals ²	270	360	271	320	243
Keynote & plenary presentations	18	34	9	14	11

¹ Includes scholarly books, book chapters, newsletters and published conference papers and abstracts (many will be peer-reviewed). Excludes video and social media.

² 2009 includes scholarly books and papers presented at international conferences; other years' data are only for scientific papers in journals with formal peer-review processes.

Our scientists have extensive networks of collaborative research with overseas researchers. The following graphs show the number and diversity of overseas co-authors on peer-reviewed scientific papers.



The number of times a published paper is cited by other authors is a measure of its impact. More than 80% of scientific papers in the world are cited less than 10 times ever; at least 40% are never cited at all despite being read by colleagues. The graph (left) show the impact of the top papers published by our staff over the last 10 years.

VII. HUMAN RESOURCES

We are committed to our values of manaaki tangata and EEO in developing a highly skilled, engaged workforce for current and future needs (see pages 36–37). Our staff have an opportunity to discuss both science management and operational issues at twice-yearly roadshows by the Chief Executive and senior managers to all sites, the bi-monthly Leadership Group's 2-day meetings, the staff engagement survey, H&S and field safety forums, voluntary site sustainability groups, feedback and suggestion box options on our intranet, and an open-door policy across all staff. We have a culture where staff are never reticent in expressing views, asking questions and providing constructive suggestions. Nearly half our staff belong to the PSA (the voluntary union) and our company supports the PSA's Partnerships for Quality approach.

We are members of the EEO Trust and are fully committed to providing equal opportunities for staff regardless of gender, ethnicity or disability. About one-third of our staff are from overseas and we welcome the cultural diversity as well as the international connectedness this brings. We are supporters of the Mainstream Programme for people with disabilities.

We report comprehensively on our good employer performance on our sustainability web pages.

Human resources	2008 Actual	2009 Actual	2010 Actual	2011 Target	2011 Actual
Total staff (FTEs) in Landcare Research	394	383	377	398	379
In science teams ¹	288	269	263	250	261
-with postgrad quals (HC)	225	246	210	-	210 ⁴
In science support ²	46	45	43	45	45
In general support ³	60	69	71	72	73
Sirtrack staff	44	38	40	32	36
Women (% science team staff)	34%	31.2%	36.1%	>40%	37.6%
Women recruited (% science team staff recruited)	40%	42.9%	38.1%	-	62.5%
Māori science staff (HC)	NA	8	10	10	<29
Lost-time injuries	7	6	3	<8	1
Days lost per lost-time injury	2.3	1.5	1.7	<2	1.8
Staff turnover	10%	12.6%	9.2%	<10%	14.7% ⁵
Turnover of key senior scientists ⁶	0	6%	0	<5%	3.4%

¹ Science teams: staff members directly involved in the production of specified research outputs.

² Science support: Staff members whose work logistically supports the outputs of the research teams but whose work could not of itself be described as research, for example: IT support staff, laboratory assistants, librarians, research report editors, general nursery and workshop staff.

³ General support: staff members whose activities support the generic, non-research infrastructural (management and general support) component of the CRI, for example: management, business development, commercialisation, financial, secretarial, stores, grounds and buildings.

⁴ In addition, 23 science support and 18 general support staff also have postgraduate qualifications.

⁵ Turnover across all staff; 2010/11: science teams =10.7%, science support = 4.1%, general support = 18.5% (13 staff transferred to our carboNZero subsidiary on 1 July 2011; they are not included in turnover.)

⁶ Science general managers, science team leaders and band 6 scientists.

VIII. ENVIRONMENTAL PERFORMANCE

We report comprehensively on our environmental performance on our sustainability web pages with summary information on page 39 of this report.

Environmental impacts	2008 Actual	2009 Actual	2010 Actual	2011 Target	2011 Actual
Motor vehicle (km/FTE)	1,690	1,516	1,138	-	1,660
Domestic air (km/FTE)	5,289	4,662	4,715	<4,000	6,024
International air (km/FTE)	8,594	9,393	9,738	<10,000	12,321
Total energy (KWh/FTE) ¹	8,992	9,238	9,489	<8,910	8,790 ²
Imputed CO ₂ (tonnes)	2,389	2,925 ³	2,825	<2,500	2,718 ⁴
CO ₂ offsets	2,390	2,925	2,825 ⁶	<2,500	2,679 ^{5,6,7}
Avoidable waste to landfill (kg/FTE)	4.15	3.12	1.25	<2	2.12
Water used (megalitres) ⁸	8.4	10.5	10.3	<9.8	11.2
Native animals killed through by-catch ⁹	6	2	0	<15	21 ¹⁰

FTE figures averaged across the entire year. All data exclude Sirtrack.

¹ Includes electricity, reticulated gas and coal.

² Total energy decreased 8% overall (7% per FTE) from 2009/10. Overall we used 52,427 kWh /\$m revenue.

- Our goal was to increase our use of renewable energy wherever possible. Unfortunately, as from 1 July 2010, Meridian could no longer guarantee renewable energy and we currently have no other renewable energy options at this time.
- Electricity consumption decreased by 13% (12% per FTE) from 2009/10. Contributing factors include an unseasonably warm May and June; and improved metering, monitoring and management due to a joint project between Landcare Research, EECA and Energy Solution Providers (ESP).
- Gas usage increased by 14 % (15% per FTE).
- Coal usage increased by 9% up (10% per FTE).

³ Includes 924 t CO₂e from a refrigerant leak at our Auckland site.

⁴ We produced 42.8 t CO₂e/\$m revenue. This economic impact calculation includes embodied emissions.

⁵ Excludes 39 t CO₂e of embodied emissions from building the new GHG facility; these are one-off, non-operational and do not require offsetting.

⁶ 2009/10 includes 425 t offset by carboNZero-certified Meridian renewable energy but this option was not available in 2010/11.

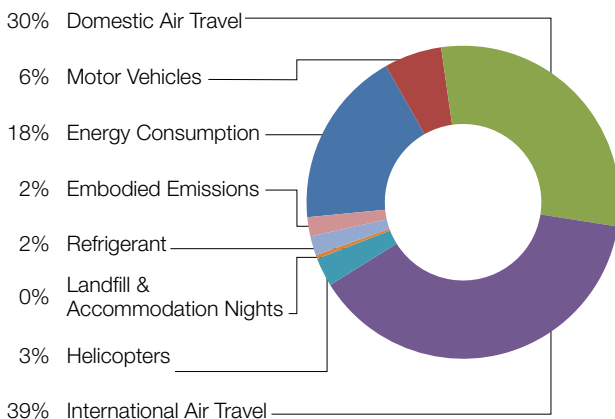
⁷ Carbon credits purchased through the carboNZero programme were derived from the Beijing 48 MW Guanting Wind Power Project.

⁸ Data recorded across our 5 main sites, which house 97.5% of staff and all laboratories.

⁹ Data reported per calendar year, as required by the Ministry of Agriculture and Forestry (MAF).

¹⁰ There were 10 studies involving routine trapping of pests, with 3542 target pests caught. Despite considerable effort to exclude birds from trapping tunnels, 22 native birds were caught and unfortunately 21 died; 19 were South Island robins.

Source of our greenhouse gas emissions (2718 t CO₂)



We produced
42.8 t CO₂e/\$m revenue.

We used
52,427 kWh /\$m revenue.

THE CAPABILITY FUND: DEVELOPING OUR SCIENCE

Administered by MSI (MoRST when the projects below were chosen), the Capability Fund helps CRIs retain and develop capability for the benefit of New Zealand.

We made allocations based on:

- A balance of capability maintenance and new and over-the-horizon capabilities covering a spectrum from targeted research through to product development
- Integration across science disciplines and outcomes
- Alignment with stakeholder emerging needs
- Support for projects (mainly Informatics) that underpin all eight Impacts.

2010/11 Capability Fund investment for each Outcome and Impact

Outcome	Impact	\$000s	%
Outcome 1 Biodiversity ¹	1.1 Biodiversity trends	1,050	19
	1.2 Biodiversity management	1,430	26
Outcome 2 Land resources	2.1 Land resource trends	756	14
	2.2 Sustaining land resources	367	6
Outcome 3 Terrestrial greenhouse gases (GHG)	3.1 GHG trends	40	1
	3.2 GHG mitigation & sinks	466	9
Outcome 4 Sustainable industry	4.1 Trends in complex environmental challenges	550	10
	4.2 Integrated environmental solutions	444	8
Underpinning projects	Projects spanning all eight Impacts	372	7
Total		5,475	100

¹ Although 45% of the funding was used for projects primarily under Outcome 1, many of those projects have significant secondary impacts under other Outcomes.

Capability Fund Project Examples

Impact 1.1 Systematic biodiversity assessment – new reporting at multiple scales

With terrestrial biodiversity loss under the public spotlight, we used our research experience and databases to develop a framework to help identify priority places, pests and outcomes for conservation management. This project assisted DOC's National Heritage Management System by demonstrating the benefits of national terrestrial biodiversity indicators, and led to agreement among regional councils on a national set of indicators. Our research also raised awareness about the biodiversity implications for some intensive land use and water allocation issues in New Zealand.

Impact 1.1 Integrating phylogenetics and ecology

The conservation management of New Zealand beech (*Nothofagus*) forest will benefit from this project that developed microsatellite markers (DNA sequences) to get a better understanding of the phylogenetics (the evolutionary

relatedness of groups of organisms) of beech forest ecosystems. The markers developed for beech, which are currently being screened, will provide the first detailed study of the population history of these important New Zealand forest species. Combined with our extensive ecological data on beech forest, the genetic data will be used to create a framework for mapping trait variation. In addition to studying the DNA of the trees, our researchers gained valuable insights by also studying the DNA of invertebrates and fungi associated with beech trees at each location.

Impact 1.2 Kauri under threat

Together with other agencies, we have been monitoring the distribution of the exotic *Phytophthora* (PTA) disease in northern kauri forests and have been studying its origins. Our DNA analysis and collaborative work with international agencies suggests the disease could have originated from Taiwan. Understanding the origin of PTA is important in designing appropriate quarantine actions that counter the disease spreading. From our multi-gene sequence alignment, a PTA-specific assay has been developed to increase the speed and accuracy of PTA detection.

Impact 1.2 Fertility control

While we have developed a vaccine that can significantly reduce possum fertility, the challenge has been to find an effective method of delivering it. In this project we have been researching oral delivery using a replication-limited recombinant vaccinia virus (recVV) expressing a test antigen. When we delivered recVV to the nose and mouth of possums, a single dose elicited an immune response to the test antigen in most animals. The next step will be to modify the virus to express contraceptive antigens and study the long-term fertility and immunity responses. As well as showing excellent potential for the successful delivery of fertility or disease control vaccines to wild possums, recVV may have applications for fertility control of other vertebrate pests.

Impact 2.1 Global Soil Map opportunities for pedometrics in New Zealand

Landcare Research is committed to the Global Soil Map (GSM) initiative (see page 29). This project was to ensure we maximised the GSM benefits for New Zealand by developing our capability in pedometrics – the application of spatial mathematics to soil science and applied in digital soil mapping. We employed an additional pedometrician, strengthened our international research linkages, and have developed and tested new techniques for soil assessment. We are also incorporating GSM methods into our domestic soil mapping project S-map.

Impact 2.2 Managing for multiple ecosystem services

Many landowners are grappling with trade-offs. Managing biodiversity, for example, may affect ecosystem services such as carbon sequestration, water quality and erosion control. This project brought together science staff with a diverse range of skills to create a framework for quantifying those trade-offs. The framework was demonstrated at the property scale (St James Conservation Area) and catchment scale (Manawatu), and also provided valuable input into DOC's new framework for measuring biodiversity.

Impact 3.2 Biofilters to mitigate landfill methane emissions

From 2013, landfill operators will have obligations under the Emissions Trading Scheme (ETS) for their greenhouse gas emissions. Landfill gas is not collected at 80% of active New Zealand landfills, exposing the operators to a potential total cost of \$28m per year (at a CO₂e price of \$25 per

tonne). A low-cost mitigation option is required for many of the smaller landfills where gas combustion to produce electricity is not feasible. We have been investigating the use of methanotrophs (methane-eating bacteria) based on biofilter technology that has successfully consumed about 95% of methane emissions from a dairy farm effluent pond. We have investigated two approaches for mitigating methane emissions from landfills using methanotroph-rich soils. Midway through the 2-year programme the results are looking promising. In particular, our analysis of landfill soils is suggesting an active soil cap biofilter is capable of high and sustained rates of methane removal.

Impact 4.1 More than just sheep: exploring farmer heterogeneity in an agent-based land use model for New Zealand

Agent-based modelling (ABM), the integration of a realistic set of decision makers and their behaviour within a model, has a lot to offer our understanding of changes in New Zealand's land use. For example, ABM will enable us to better predict the land-use implications of policy and societal changes within the agricultural sector. Using existing information on farmer types, perceptions and motivations, we explored how social changes (such as changes in the rates of succession), economic changes and changes in their information networks can result in spatial changes in land use.

Impact 4.2 Sustainable multi-function management of pests on Māori land

As the number of iwi reaching Waitangi Tribunal settlements with the Crown increases, so too is interest in research to help Māori achieve their economic, cultural and environmental aspirations for their land. We are investing in the development of relevant skills and experience, and the broadening of some long-established relationships with iwi. In this project we are working with the Tūhoe Tuawhenua Trust to help develop an economic model for the sustainable harvest of possums. With strong demand for possum fibre, there is growing interest in the sustainable harvest of possums in accessible areas of forest. Our model will help determine the optimal trapping frequency and trap-line spacing for the sustainable harvest of possums. Iwi want to kill sufficient animals for commercial success and to protect the forest, without jeopardising the long-term sustainability of the operation. Working with full-time possum harvesters and using our extensive information about possum behaviour and control, we are developing a model that considers variations in trapping effort, possum density and economic variables.

DIRECTORY ◀

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Jo A Brosnahan (Chair)
Graeme S Boyd (Retired 30 June 2011)
Prof. W Grant Guilford
Hon. M John F Luxton
Robin Pratt (Resigned 31 December 2010)
Peter M Schuyt
Tania J Simpson
Victoria A Taylor
Dr Emily J Parker (From 1 July 2011)
Gavan J Herlihy (From 1 July 2011)

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Dr Richard FS Gordon: Chief Executive Officer (From 25 May 2011)
Previously General Manager Environment & Society
Dr Warren J Parker: Chief Executive Officer (Resigned 22 February 2011)
Carol R Bellette: Chief Financial Officer
Katrina F Direen: General Manager People & Performance
Mike S Lee: General Manager Business
Dr David P Choquenot: General Manager Biological Systems
Dr Alison J Collins: Acting General Manager Environment & Society (From 1 July 2011)

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Photo Credits:

- PG 1 *Dale Norbury, Auckland Council, Adrienne Farr, Chris Pratt, Helene de Meringo, Robyn Simcock*
- PG 10 Ferns, mosses and liverworts make a significant pervasive contribution to ecosystem functioning.
John Hunt
- PG 14 Intensive pastoral farming
John Hunt
- PG 18 Carbon sink potential of exotic forests (blue = high; green = moderate; red = low)
John Dymond, Anne-Gaelle Ausseil, Miko Kirschbaum
- PG 22 'Go' for green business
Cissy Pan
- PG 26 Diana Prada (L) and Dianne Gleeson (R) of EcoGene with Silvana Tridico (Murdoch University) and Professor John Cooper (Cambridge University) at the first ever Wildlife Forensics Workshop and Symposium.
Richard Jakob-Hoff, Auckland Zoo
- PG 36 Katarina Tawiri and Anna Mae Burd weaving a large wāriki to cover tables at site Mātārīki celebrations
Adrienne Farr
- PG 42 Fieldwork camp in the Waimana catchment, near Te Urewera National Park
Caroline Thomson



ANNUAL
REPORT
2011 PART I



Landcare Research
Manaaki Whenua