

# ANNUAL REPORT 2013

## Environmental Performance with Integrity

Part One



Landcare Research  
Manaaki Whenua

Landcare Research New Zealand Limited  
(Manaaki Whenua)  
Annual Report 2013

Part 1:  
Environmental Performance with Integrity  
ISSN (print) 1172-7942  
ISSN (web) 1177-9969

Part 2:  
Directors' Report and Financial Statements  
ISSN (print) 1172-9996  
ISSN (web) 1173-0277

ANNUAL REPORT 2013  
Our Annual Report is in two parts—together they fulfil our annual reporting responsibilities under the Crown Research Institutes Act 1992. Detailed information about our research, operational activities and governance is available on our website:

[www.landcareresearch.co.nz](http://www.landcareresearch.co.nz)

Cover photo:  
Landcare Research worked with Waterfront Auckland to design the extensive raingardens for the Wynyard Quarter transformation. The gardens capture and cleanse stormwater runoff. *Alison Greenaway*



# LANDCARE RESEARCH AT A GLANCE



John Hunt

## Our Core Purpose

Landcare Research's Core Purpose is 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.

- Land cover, land use capability and effects, and spatial land information that integrates across sectors and scales
- Integrated social and biophysical research to support the sustainable management of terrestrial biodiversity and land resources

## Our National Outcomes

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

Landcare Research works with other research providers and end-users to contribute to the following:

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

## Our Scope of Operation

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

- Terrestrial vertebrate pest control
- Catchment-level ecosystems (including wetlands) and related ecosystem services
- Terrestrial carbon processes and inventory, and other greenhouse gases from soil and land
- Soil characterisation, processes and services

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

Our Māori name means to care for the land in all senses. Māori are tangata whenua, the indigenous people with whom we consult and collaborate. Our recognition of and respect for Māori as tangata whenua is reflected in our Guiding Philosophy and the Voices for Sustainability pages of our public website:

[www.landcareresearch.co.nz](http://www.landcareresearch.co.nz)

## Deriving National Value from Core funding

Each year, we add a number of new innovation case studies to our website to illustrate benefit to New Zealand from Core-funded research. These case studies can be found at [www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

The latest innovation case studies are referenced in this report:

### Biodiversity Outcome

- Botanists identified several new plant species and assessed the threat status of all lichen species in New Zealand. Our biological collections and expertise underpin biodiversity reporting (pages 12 & 46)
- Research and knowledge transfer have led to increased protection for some naturally uncommon ecosystems, e.g. rocky outcrops, dryland ecosystems and frost flats (pages 13 & 49)
- New understanding of what triggers mast seeding is enabling DOC to adopt more strategic pest control to protect biodiversity from pest irruptions (page 14)
- Improved pest control technologies and strategies benefits the Sanctuaries of New Zealand Network and will be vital to progressing the Predator-Free New Zealand vision (page 49)

### Land Resources Outcome

- Extended coverage of S-Map Online supports on-farm and regional-scale land management decisions (page 18)
- New information about the extent of stony soils in New Zealand and their suitability for agricultural development supports land and water management decisions (page 18)
- The Land Resource Information System (LRIS) is a nationally-significant evidence-base used by land management and policy agencies throughout New Zealand (page 8 & 44)

### Greenhouse Gases Outcome

- Our national scale assessment of the Land Use and Carbon Analysis System provides MfE with confidence that the plot network is reliable (page 25)

### Development within Environmental Limits Outcome

- NZFARM is being used to assess the effectiveness of policy options to manage multiple environmental constraints and optimise economic benefit (page 30)
- Participatory processes for freshwater management are helping local government resolve contentious issues in a rapidly changing 'water environment' (page 31)
- Indigenous forestry can benefit from new understanding of beech management systems and the impact of selective harvesting of dominant tawa trees to help restore podocarp forest (page 31)
- Biosecurity agencies are benefitting from our International Collection of Micro-organisms from Plants and a DNA barcode database for one of the worst plant pathogens (*Colletotrichum*) (page 32)
- Auckland Council has adopted our framework for increasing Māori involvement in resource management issues (page 35)

In addition to the case studies, our website provides extensive information about our highly diverse and innovative research, stakeholder engagement, plus access to resources and information in our nationally-significant databases and collections via various portals. We also discuss how our science links with our sustainability reporting.

# CONTENTS

## Our Organisation

Landcare Research was formed in 1992 and is one of the seven current Crown research institutes (CRIs). CRIs function as independent companies but are owned by and accountable to the New Zealand Government. Our shareholders are the Minister of Finance and the Minister of Science and Innovation, and we work as part of the Crown to deliver benefit to New Zealand.

We have 333 staff at nine locations across New Zealand, including our subsidiary carboNZero Holdings at Lincoln and Auckland. (On 1st July 2013, carboNZero Holdings merged its existing services with those of Enviro-Mark®; the new company is called Enviro-Mark Solutions Limited.)

We collaborate extensively with other research organisations in New Zealand and around the world. Our science revenue (about \$55 million per year) is derived primarily from contracts with the Ministry of Business, Innovation and Employment (MBIE), Ministry for Primary Industries (MPI), Department of Conservation (DOC), Ministry for the Environment (MfE), Animal Health Board (AHB, now called TBfree New Zealand and a part of OSPRI), local government, private sector businesses and organisations, and Māori organisations.

The Government appoints our Board of Directors, and invests significant accountability in them for deriving value from publicly-funded science and innovation – Landcare Research receives approximately \$24 million per year of Government revenue from MBIE in a Core Funding Agreement. The shareholding Ministers expect the Board to take strategic advice both from internationally-leading scientists and key New Zealand stakeholder partners through our Science Advisory Panel and Outcome Advisory Panel. The Board reports to shareholding Ministers on Landcare Research's activities, impacts and achievements and progress towards the four National Outcomes of our Core Purpose.

Landcare Research at a Glance.....	01
Innovation Case Studies.....	02
Chair & Chief Executive's Review.....	04
Stakeholder Engagement in our Science Framework.....	07
Biodiversity (Outcome 1).....	10
Land Resources (Outcome 2).....	16
Greenhouse Gases (Outcome 3).....	22
Development within Environmental Limits (Outcome 4).....	28
Vision Matāuranga .....	34
Science Excellence & Collaboration.....	36
Informatics & Systematics.....	43
Knowledge & Technology Transfer.....	47
Our Organisation.....	51
Summary of Financial Performance.....	58
Directory.....	60
Glossary .....	Inside back cover

# CHAIR & CHIEF EXECUTIVE'S REVIEW



Landcare Research exists because New Zealanders and our trading partners care about our natural environment. Whether in business, on the farm, in urban communities or in their recreation, New Zealanders want their natural environment to be healthy because it is central to the identity, liveability and future prosperity of the nation.

Repeatedly we see evidence that our trading partners value the integrity of our products; and that integrity is linked to human and environmental health. Landcare Research provides an understanding of the health of the natural environment and tools that will help protect that health and support the integrity of our exports and national brand. Therefore the value we add can be summarised as supporting '*environmental performance with integrity*'.

The people in Landcare Research work with our stakeholders in business, government and the community to make the results of our work readily accessible and useful. Our work covers a spectrum from basic science that advances knowledge, through applied science that puts knowledge to work to achieve specific outcomes, to the provision of services such as our environmental performance certification programmes.

As a Crown research institute we provide a globally unusual but advantageous model, the envy of many, in which scientists can link readily to diverse disciplines in the same organisation and also with policymakers and businesses.

Success in our endeavour owes a great deal to our ability to form and lead effective teams across organisational and discipline boundaries and work towards jointly-owned goals for the benefit of New Zealand.

At the heart of our contribution is excellent science. It is notable that from 2005 to 2012 Landcare Research produced 14% of all science journal publications from CRIs and New Zealand universities in the environment/ecology subject area. We also published 24% and 15% respectively of New Zealand's soil science and biodiversity conservation publications. The impact of Landcare Research's publications, measured by average citations per document, was higher than for any other CRI or New Zealand university in all three research areas (Incites database). Our biodiversity /conservation publications received over twice as many citations as the global 'average' paper in this research area.

The advent of Core Purpose definition and Core funding (half of our total revenue is on a long-term contract with government) has enhanced the ability of Landcare Research and other CRIs to work in a much more joined-up way across the research system. It has shifted the focus from competition for funds to forging 'best teams with shared goals'. With the coming National Science Challenges, such performance is going to be even more critical as we step up further in seeking the benefits of



multidisciplinary science and innovative stakeholder engagement.

Land and water is a theme of major significance to government entities, the primary sector, industry and communities in New Zealand. This is reflected in its presence in the list of National Science Challenges. The Government's policy emphasis has been on enhancing freshwater quality, water availability and mechanisms of allocation. Landcare Research's contribution in 2012/13 has spanned a broad spectrum from modelling the availability of water in catchments, making information available about soils and the likely risks of nutrient loss from agricultural systems, developing tools for variable-rate irrigation, to linking models of economic development and environmental impact in support of policy development at catchment, regional and national levels. For the first time in New Zealand, a detailed empirical survey (page 30) has been undertaken (by Landcare Research) on farmer behaviour to inform land use and water quality policies.

New Zealand's biological heritage is a second theme of major importance to the New Zealand public, primary sector and government and also the focus of a National Science Challenge. Our country's indigenous flora and fauna are of national and global significance and a major part of Landcare Research's work is focused on understanding these natural assets so that they can be nurtured alongside necessary economic activities for the benefit of present and future generations. Increasingly, businesses are taking a genuine interest in New Zealand's biological heritage and recognising that economic growth and enhancement of the natural environment can be a 'both, and' rather than 'either, or'. Landcare Research is at the forefront in supporting this change of mindset with strong science and valuable tools. Examples from 2012/13 include developing consistent biodiversity measurement approaches that help understand trend, impacts and risks; developing ecological restoration technologies for threatened habitats, which can contribute to offsetting of impacts; and developing innovative pest and biosecurity management tools, which help to reduce damage and risks in both indigenous and production ecosystems.

Achieving recognised certification for environmental performance is a goal of around 400 corporate customers of our carboNZero<sup>Cert</sup>™, CEMARS® and Enviro-Mark® programmes. To enhance our service and provide further

opportunities to those customers, we combined all three programmes in our wholly-owned subsidiary, renamed Enviro-Mark Solutions. We continue to see clear evidence of the value customers put on environmental performance certification and its potential to reduce risk and enhance sales and exports. The total carbon emissions footprint of the global clients under management in the CEMARS and carboNZero programmes (over 130 million tonnes carbon dioxide equivalents) now exceeds the total New Zealand annual emissions footprint (around 70 million tonnes).

Alongside our science to enhance environmental performance with integrity, Landcare Research is committed to sustainable business practice in its own operations. In our public sustainability web pages ([www.landcareresearch.co.nz/about/sustainability](http://www.landcareresearch.co.nz/about/sustainability)), we report extensively and comprehensively on our sustainability performance and how it integrates with our science. This year has seen notable improvements in our 'environmental footprint' with substantial reductions compared with recent years' absolute levels of energy use, carbon dioxide emissions, water usage and waste to landfill. Our targets for the 2013/14 year will be to do even better. Our Guiding Philosophy, Sustainability Policy and Ethics Principles are also available on our public website ([www.landcareresearch.co.nz/about/about-landcare/principles](http://www.landcareresearch.co.nz/about/about-landcare/principles)).

Throughout our science, Landcare Research works with tangata whenua (the Māori people, their organisations and businesses). The inseparable relationship that Māori recognise between mankind and its natural environment is reflected in our approach to achieving national outcomes – an approach that integrates social, economic and environmental dimensions. Projects in 2012/13 have helped Auckland Council and Māori stakeholders to implement a suitable planning framework that incorporates Māori perspectives, and helped Ngāi Tūhoe to realise sustainable development opportunities (e.g. harvesting indigenous trees) resulting from their Treaty of Waitangi Settlement with the Crown. Landcare Research also joined 'Te Kōkiri mō te Whāinga Hua o Ngā Whenua Māori', a new initiative to raise productivity of Māori land, which is the private sector's response to the Māori Economic Development strategy 'He Kai kei aku ringa', produced by the Māori Economic Development taskforce.

During 2012/13 we have actively promoted a special national collaboration opportunity, the Productive Land

Innovation Cluster that is focused on five partners at Lincoln. This was launched by the Science and Innovation Minister Steven Joyce and the Primary Industries Minister Nathan Guy in April. The cluster is founded on a shared vision to increase the value obtained from the land while enhancing environmental quality. This is an important opportunity to share facilities and resources in the interests of building sector capability, coordinating science and enhancing its uptake through close involvement with users in public and private sectors.

Working closely with our stakeholders is critical to our effectiveness. Therefore we are pleased that a stakeholder perception survey conducted for MBIE has returned positive results once again – 95% of respondents had adopted knowledge or technology from Landcare Research since 2010 and 92% were satisfied with that experience; 85% had confidence that Landcare Research has the ability to put together the most appropriate research teams and 78% were satisfied with the way Landcare Research sets its research priorities; and 91% of respondents were satisfied with the overall quality of experience of interacting with Landcare Research. Feedback is enormously valuable and points us to areas for continuous improvement, for example, in our understanding of client priorities and the availability of our staff.

Making our scientific information more readily accessible by all users and enhancing the ability of scientists to collaborate through sharing data and accessing computing ‘grunt’ have long been drivers for our Informatics group, established in 2006. In 2012/13 we continued to grow our usage of the National e-Science Infrastructure, which puts enormous computing capacity at the fingertips of our scientists – analyses that took days now run in minutes, bringing ‘big data’ opportunities within reach. Working with regional councils and other CRIs we grew the ability of our National Land Resource Centre to make information from multiple organisations available through a single portal. We increased coverage of S-Map Online (a web-accessed

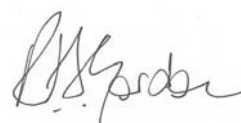
repository of soils information) and have begun trials to link it to the widely used OVERSEER® model for farm nutrient management. We also started development with Antarctica New Zealand of a web portal and research collaboration resource for use by all Antarctic Treaty partners.

Our financial performance in 2012/13 reflected responsiveness to tight financial conditions and changing science needs in our business environment. Our group revenue of \$55.6m was \$3.7m (excluding Sirtrack, page 58) less than in the previous year. We held costs at \$2.5m less than the previous year and incurred \$753k restructuring costs in better positioning the company for changing science needs. Seventeen (full-time equivalent) redundancies across science and support roles reflected both a deliberate reduction of capacity in certain science areas and also a drive for increased efficiency in support services. We continue to recruit and build capacity in areas of science growth, including resource economics and Māori-related science. While redundancies are regrettable and difficult for the staff, we are pleased that four of the affected scientists have stayed with us in a voluntary capacity as Research Associates. Our group return on equity of 4.1% (budget 4.2%) was reduced to 2.1% by restructuring costs. Landcare Research remains in a strong financial position with an equity ratio of 61% (56% prior year) and net gearing ratio of 0% (0% prior year).

We look forward to the new developments taking place in 2013/14 with National Science Challenges, science clusters, potential legislation for national ‘state of the environment’ reporting, strong national focus on natural resources and land and water in particular, and steady growth in support for sustainable business practices, expressed through the growth of the Sustainable Business Council, which is now a part of Business New Zealand. We will continually seek to grow the value that we add across private and public sectors as we support *environmental performance with integrity* as a national asset.



Peter Schuyt  
Chair



Dr Richard Gordon  
Chief Executive



# ENGAGING STAKEHOLDERS IN OUR SCIENCE FRAMEWORK



## GOALS

1. Landcare Research's partnership with central and local government, industry and Māori organisations is valued by them as a way of improving the efficiency and effectiveness of science expenditure that leads to National Outcomes being achieved.
2. Landcare Research's science framework is clear, effective and facilitates engagement with stakeholders who support our approach to achieving our Core Purpose and National Outcomes.

## Our key stakeholders

Our most significant stakeholder partners are members of the Natural Resources Sector in government: the Ministry for Primary Industries (MPI), the Ministry for the Environment (MfE), the Department of Conservation (DOC), also OSPRI (which includes TBfree New Zealand, previously AHB), several Māori organisations, local and regional government and clients in the certification programmes run by Enviro-Mark Solutions Ltd. While we work with those businesses directly, strategic engagement with the private sector is mostly through BusinessNZ and sector bodies such as DairyNZ, the Foundation for Arable Research (FAR), the Fertiliser Association of NZ, IrrigationNZ and ZESPRI®.

Increasingly, we work directly with industry on solutions to specific issues and in enhancing environmental performance with integrity. As tangata whenua, Māori are important stakeholders and research partners – our contribution to Vision Mātauranga is explained in that

section (page 34). Engaging these stakeholders in our science planning supports the Government's Business Growth Agenda, which explicitly recognises the role of innovation in growing the export economy and the importance of science in supporting the sustainable use of New Zealand's natural asset base.

Staff from key stakeholder organisations are members of our Outcome Advisory Panel. The Panel provides a streamlined conduit for stakeholders to influence our science direction, priorities and delivery. During the year, we worked with the Panel to review investment strategies and priorities for our four National Outcomes. Changes to the investment strategies are summarised in our Statement of Corporate Intent for 2013–18, which can be found on our website at [www.landcareresearch.co.nz/publications/corporatepublications](http://www.landcareresearch.co.nz/publications/corporatepublications).

## Examples of Strategic Engagement

### National Land Resource Centre

Since the launch of the National Land Resource Centre (NLRC) in July 2012, we have worked across and within sectors (government, business and science) to develop a shared work programme to deliver high-quality and fit-for-purpose land and soils information to major end-users, determine needs of major users, and enhance science communication to key user groups. A pan-sector capability survey revealed a growing demand for short-course technical training in the use of science data and tools, so work is underway to respond to this.

The Regional Council Land Monitoring Forum and Land Managers Group have also been working with the NLRC to help ensure land and soils research is better aligned to their rapidly changing land management needs – for example in response to freshwater and RMA reforms.

While Landcare Research will continue to coordinate the NLRC, all CRI partners will collectively set direction and agree on priorities for shared work programmes. Similar discussions on potential collaborations are underway with the regional councils, government departments in the natural resource sector, and key universities.

Development of the NLRC has been supported by Landcare Research investment.

### Productive Land Innovation Hub

During the year, we worked with DairyNZ, AgResearch, Plant & Food Research and Lincoln University to develop the concept for a Productive Land Innovation Hub (aka 'the Lincoln Hub') for collaborative research, education and industry development with the goal of improving achievement of national outcomes, stimulating innovation, and building capability within the land-based and supporting agricultural industries. The Hub was officially launched on 29 April 2013. The Hub will facilitate industry–science engagement, collaborative partnerships, training of work-ready graduates for the land-based sectors, and generate opportunities to increase the economic and environmental performance of both the productive and science sectors.

### The Land Cover Database (LCDB) and Land Resource Information System (LRIS) steering groups

Robust information on land cover and land use (though less developed) is required by many agencies to underpin international negotiations, state of the environment reporting, and research. Development of the Land Cover Database 3<sup>rd</sup> edition (LCDB3, launched last year) and 4th edition (LCDB4, currently in progress) has been overseen by a steering group on which MBIE, MfE, MPI, DOC, LINZ, the NZ Fire Service and regional councils are all represented. This steering group, plus the technical advisory group and collaborator checking group, met regularly throughout the year. The LCDB projects use a 'public research consortium' approach with multiple government agencies (central and local) contributing to the research, both with financial contributions and with significant in-kind contributions, such as datasets and ground-truthing activities.

In line with the successful LCDB stakeholder engagement model, we also held a stakeholder workshop to prepare a roadmap for the future of the New Zealand Land Resource Inventory (NZLRI) and the Land Use Capability (LUC) classification system. Wide support was given indicating the future value of the existing NZLRI, not just by managing the dataset, but also by managing much of the ancillary documentation and knowledge surrounding it.

LRIS is supported by Core funding. The LCDB is supported by MBIE contestable funding with considerable in-kind support from DOC and regional councils. Both LCDB and LRIS are managed in the Characterising Land Resources portfolio.  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

## Key Performance Indicators

The Science + Innovation Group in MBIE commissioned Colmar Brunton to conduct an independent stakeholder survey across a wide range of organisations, and 57 stakeholders (61 in the 2012 survey) commented on Landcare Research:

- 78% are satisfied with the way we set research priorities (83% in 2012)
- 69% are confident that we consider their sector's priorities when setting research priorities (70% in 2012)
- 85% have confidence that we have the ability to put together the most appropriate research teams (91% in 2012)
- 95% of respondents for Landcare Research had adopted knowledge or technology from Landcare Research in the past three years (97% in 2012)
- 92% of respondents are satisfied with their experience of accessing knowledge or technology from Landcare Research (93% in 2012)
- 91% of those interacting with us in the past 3 years are satisfied with the overall quality of their experience (87% in 2012)

## Stakeholder relationships

For the year ended 30 June:	2010	2011	2012	2013
Client staff on Landcare Research advisory groups	60	69	46 <sup>1</sup>	54 <sup>1,2</sup>
Staff secondments – to other agencies	3	3	5	6
– from other agencies	1	1	1	1
Other agency staff co-located with us	100	110	102	89 <sup>3</sup>
Our staff co-located with others	7	9	10	4 <sup>4</sup>

<sup>1</sup> With Core funding we have moved to a smaller number of strategic advisory groups. Previously, advisory groups were attached to the myriad of smaller research programmes and research areas with a governance group having oversight of OBIs.

<sup>2</sup> 54 staff representing 33 agencies and groups

<sup>3</sup> DOC staff who were co-located with us at Hamilton and Lincoln sites have now moved to their own premises

<sup>4</sup> 6 of our staff were previously co-located in a building leased by Science New Zealand. This year, we leased new premises for our Wellington staff and Science New Zealand and Scion staff are now co-located with us.

Thomas Wilding (Hawkes Bay Regional Council) discussing water issues during a field trip for a workshop on participatory processes (page 31) Suzie Greenhalgh





# BIODIVERSITY



## OUTCOME

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

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

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

On the other hand, native vegetation is naturally regenerating across large tracts of retired marginal land.

Wildlife sanctuaries, largely driven by community groups, continue to enhance biodiversity across 56 000 ha of mainland New Zealand and near-shore islands. Coordinated community action, based on the best available science, will be critical to progressing the 'Predator-Free New Zealand by 2050' initiative locally, regionally and nationally.

The effective management of biodiversity requires accurate knowledge of its composition and of changes in its state through time and in different ecosystems. New Zealand's international reporting on our biodiversity also requires a systematic approach to monitoring and measurement of our biodiversity. Such an approach allows the most threatened components of biodiversity to be identified through targeted research and addressed through enhanced understanding of risk, how more effective management can be achieved, and opportunities to improve the efficiency and effectiveness of biodiversity management and policy.

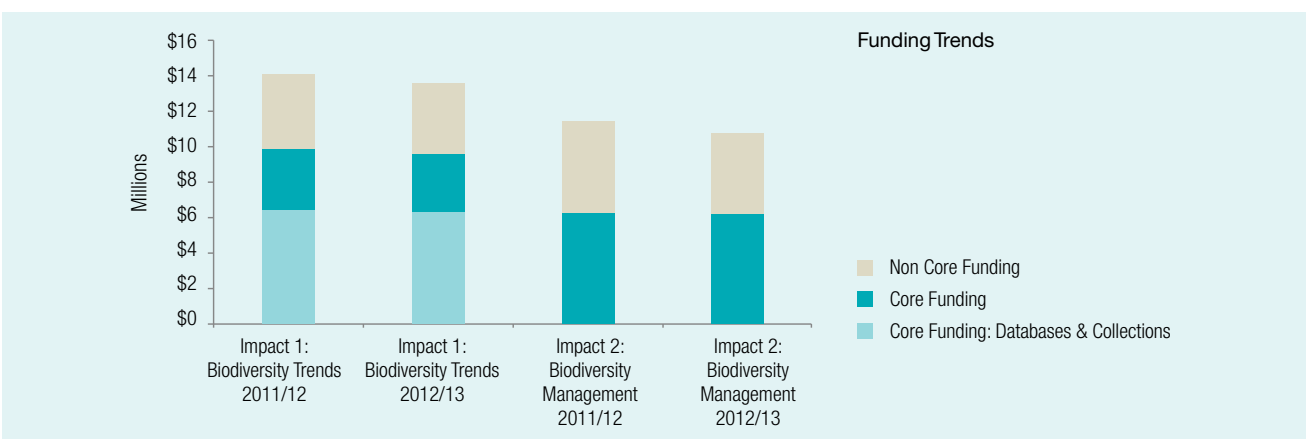
**Impact 1:** Trends in national and regional biodiversity on public and private land are understood and based on best available definitions and descriptions for species and comprehensive indices of ecological integrity.

<p><b>KPI:</b> DOC and regional councils are using comparable metrics to measure status and trend and impacts of interventions on biodiversity within their jurisdictions.</p> <p><b>2010/11 Baseline situation:</b> Various methodologies were used to assess biodiversity so it was difficult to understand national and regional trends and to assess the impact of management interventions.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>• As a basis for determining status and trend regional councils and DOC began using our <i>ecological integrity</i> metrics in their reporting, including DOC in its 2011/12 Annual Report.</li> <li>• Regional councils (through the Biodiversity Forum) and DOC (through its Planning, Monitoring, and Reporting Unit) are adopting the 'ecological integrity' concept, and its biodiversity metrics.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>• DOC's use of robust, nationally-consistent, objective metrics was instrumental in its annual reporting gaining Office of the Auditor-General approval (page 12).</li> <li>• Regional councils have a suite of metrics for monitoring biodiversity on public and private land; metrics are compatible with those used by DOC (page 12).</li> <li>• Status data are provided by our nationally significant collections. The e-Flora was extended with descriptions of one moss family and five fern families; NVS added 100 datasets for 4860 plots; information from all 70 volumes of <i>Fauna of New Zealand</i> is now available via the Biotaxa website (page 12, 46).</li> </ul>
--	---	---

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

<p><b>KPI :</b> Consents related to land use change under the Resource Management Act (RMA) are informed by a scientifically-based set of criteria that take account of cumulative effects on habitat availability.</p> <p><b>2010/11 baseline situation:</b> Resource Management Act processes were informed by a variety of evidence, with no nationally-consistent biodiversity framework or context.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>• Cumulative effects of land-use intensification on highly-threatened dryland ecosystems in inland eastern South Island were used by the Environment Court and High Court in four hearings considering resource consents for major land-use changes.</li> <li>• Landowners, business and public groups reached agreement that 100,000 ha of the Upper Waitaki Basin required protection.</li> <li>• Of New Zealand's 72 naturally uncommon ecosystems, the IUCN's ecosystem Red-List criteria identified 18 as critically endangered, 17 as endangered and 10 as vulnerable.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>• District plans, which guide resource consents, increased protection for indigenous vegetation for lower elevations in highly-threatened dryland ecosystems (page 49).</li> <li>• Court decisions informed by our science protected naturally uncommon ecosystems in the upper Hurunui / Lake Sumner margins and a significant area of North Island frost flat (page 49).</li> <li>• We participated in an international working group assessing application of IUCN ecosystem-Red List criteria and protocols to the Oceania Region, to aid biodiversity monitoring and conservation action (page 13).</li> </ul>
--	--	--

<p><b>KPI:</b> Management decisions by DOC, MPI and regional councils, aimed at reducing threats to species and habitats, are based on robust risk models that reflect best available knowledge about the efficacy, cost and acceptability of management strategies and tools.</p> <p><b>2010/11 baseline situation:</b> Management decisions largely ad hoc with inconsistent application of robust biodiversity value and risk modelling.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>• Our framework, which links species extinction rates to changes in both spatial distribution and population size, helps sanctuaries and DOC to compare likely outcomes from different management actions.</li> <li>• Updated threat listings for native biota enable DOC to reallocate resources for managing the most critically threatened species.</li> <li>• DOC and 14 councils used our risk model to rank their top weeds.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>• Decision frameworks are in use to support threatened species recovery, ecosystems protection, and regional council pest control (page 12, 13, 14).</li> <li>• DOC is using our masting model to predict and cost-effectively manage vertebrate pest irruptions (page 14).</li> <li>• DOC and the NZ Army have evidence from us that biocontrol of heather benefits indigenous biodiversity compared with herbicide control (page 15).</li> </ul>
---	--	---



## Innovations

**Impact 1 (Trends):** *Trends in national and regional biodiversity on public and private land are known and understood, on the basis of best available definitions and descriptions for species and indices of ecological integrity.*

### Consistent biodiversity data from public and private land

We have worked with DOC and regional councils to establish nationally- and regionally-consistent, robust frameworks for measuring, analysing and interpreting change in the status of biodiversity at a range of spatial and temporal scales. This benefits public and private conservation initiatives, and underpins a wide range of land management decisions.

Some key findings from a nationwide assessment of indigenous forests on public conservation land from the first year of DOC's Biodiversity Monitoring and Reporting System showed that:

- Deer and goats are common in very few forest sites, and are mostly uncommon. Overall, tree species that are palatable to introduced mammals have regenerated widely over the last decade, and show no evidence of recruitment failure.
- Four species of native birds are found on more than three-quarters of forested sites nationally.
- Invasive plants are generally uncommon in indigenous forests, although some species are widespread and merit more attention from managers.

The first-year results were used as the basis of KPIs in DOC's 2012 Annual Report. An external audit evaluated DOC's overall performance as 'good', and this was attributed in part to the evidence base provided by indicators used in the Biodiversity Monitoring and Reporting System. This evidence base will be used to help prioritise DOC's management activities and to evaluate the effectiveness of local management.

Regional councils are seeking to use comparable indicators so that a national picture of biodiversity can emerge. These same indicators have also been used in some primary sectors (e.g. kiwifruit orchards) to compare how different management regimes affect bird populations. Many of the indicators make use of existing datasets.

Where new datasets are needed, we are working with regional councils and DOC to coordinate, rather than duplicate, monitoring and data collection efforts.

This research is part of the Measuring Biodiversity Change portfolio, and was supported by Core funding, DOC, Envirolink and regional councils.

### Climate change may benefit Adélie penguin colonies

We developed software to semi-automate the penguin counting and validation of aerial surveys, enabling experienced counters to rapidly assess the Adélie colonies, check other counters to ensure consistency, and save these counting efforts for future research work. Using satellite imagery it will now be possible to estimate the total number Adélie penguins in Antarctica and monitor changes across regions and time in response to sea ice conditions and anthropogenic activities (e.g. commercial fishing).

Colony size of Adélie penguins on Beaufort Island, in the southern Ross Sea, has increased as receding glaciers make more nesting habitat available. Dispersal rates of Beaufort Island birds to nearby colonies also declined as more nesting habitat became available. Analyses of aerial photography (beginning in 1958) and modern satellite imagery showed that colony size has varied with available habitat, but in the last decade both colony size and habitat availability have increased. In accord with glacial retreat, summer temperatures at nearby McMurdo Station have increased by ~0.50°C per decade since the mid-1980s. These results concur with predictions that major ice shelves and glaciers will retreat rapidly elsewhere in the Antarctic, potentially leading to increased breeding habitat for Adélie penguins. The published paper captivated the news media, with research being reported by numerous news and science agencies around the globe.

This research is part of the Measuring Biodiversity Change portfolio, and was supported by MBIE contestable funding via a subcontract from NIWA.

### New plant species and species status

Systematics staff continued to provide data on status and trends of native species for biodiversity managers. Publication of research (collaborative with DOC, University of Otago, Unitech) on the conservation status of lichens indigenous to New Zealand exemplifies our continued work in data deficient and threatened species with DOC. The list comprises 1799 formally accepted taxa, including 11 'Threatened', 176 'At Risk', and 975 'Data Deficient'. A further 636 taxa were considered 'Not Threatened'. Five lichens may warrant further conservation attention once their taxonomic status is clarified.



This year, a revision of coastal cresses (*Lepidium*) recognised 11 new native species; all have high conservation values and are actively managed by DOC. Other new species include two new species of alpine *Gingidia*, a highly unusual *Cardamine* (bittercress) and a wire rush (*Empodisma robustum*) that is a dominant component of the rare and ecologically important domed peat bog habitats of the Waikato, and two new fern species (*Hymenophyllum pluviatile* and *Gleichenia inclusisora*). New additions to the New Zealand flora include an unknown moss collected on Stewart Island and identified as *Tayloria tasmanica*, a rare species previously only known from Tasmania, and a species of an Australian *Centrolepis* bristlewort and two species of *Sticherus* umbrella ferns. These are significant new discoveries that will require monitoring and further survey by DOC.

The nationally significant Allan Herbarium plant collection is key to this research in the Defining Land Biota portfolio, and is Core funded [www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

**Impact 2 (Management):** Frameworks are in place to ensure the most threatened ecosystems, habitats and species are managed to reduce the risk of decline in native biodiversity.

### Rocky outcrop ecosystems on Banks Peninsula

The rocky outcrops on Banks Peninsula are a naturally uncommon ecosystem. This year the Banks Peninsula Conservation Trust and QEII ran a rocky-outcrops field day for 90 landowners and we delivered the keynote address. Ongoing work with these two agencies, Christchurch City Council and ECan has led to targeted weed and pest control efforts to ensure the perpetuation of threatened biota and associated unique ecosystems. The upsurge of official interest has been matched by private landowners covenanting rocky outcrops.

Our field research showed that the volcanic rocky outcrops on Banks Peninsula support 350 vascular plants; thus more than a third of the Peninsula's flora occurs on 5% of the landscape. Some 63 species are found only on outcrops, and many are rare, including 4 of the 8 taxa endemic to Banks Peninsula. Although the community appreciated the striking visual impact of these outcrops, there had previously been limited awareness of their importance for biodiversity.

This research is part of the Managing Biodiversity portfolio. Ongoing interaction with the groups mentioned is supported by Core funding. [www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Ecosystem risk assessments

The International Union for Conservation of Nature (IUCN) has traditionally focused on identifying the world's most threatened species. The IUCN has now proposed a new quantitative approach to assessing risk to ecosystems, based on changes in the extent of ecosystems, environmental degradation, and disruption of biotic processes. In recognition of our work last year in undertaking a threat assessment of New Zealand's 72 naturally uncommon ecosystems, Landcare Research was invited to join a high-profile international working group developing the IUCN Ecosystems Red-List protocol.

The IUCN criteria assess four distributional and functional symptoms of ecosystem decline: (1) decline in ecosystem distribution; (2) restricted distributions with continuing declines or threats; (3) environmental (abiotic) degradation; and (4) disruption to biotic processes. A fifth criterion (quantitative estimates of the risk of ecosystem collapse) enables integrated assessment of multiple processes and provides a conceptual anchor for the other criteria.

A trial of the protocol on terrestrial, subterranean, freshwater and marine ecosystems from around the world shows that its concepts are workable and its outcomes are robust, that required data are available, and those results are consistent with assessments carried out by local experts and authorities. The new protocol provides a consistent, practical and theoretically grounded framework for establishing a systematic Red List of the world's ecosystems. This will complement the Red List of species and strengthen global capacity to report on and monitor the status of biodiversity.

This research is part of the Managing Biodiversity portfolio and was supported by Core funding. The IUCN Working Group workshops have been supported by the Australian Centre of Excellence for Environmental Decisions and the Australian Centre for Ecological Analysis and Synthesis.

### Pest control to improve tree survival

A new, user-friendly model to help target herbivore control has been developed. The model was developed for DOC to predict the level of herbivore control required to increase tree survival to acceptable levels and provide quantitative estimates of the benefits for forest health of current herbivore management strategies at specific sites. The model will enable DOC and AHB (now TFree New Zealand) to prioritise possum control at local and regional scales to protect tree species at risk of mortality.

This research is part of the Managing Invasive Weeds, Pests and Diseases portfolio, and was supported by DOC funding.

### Effectiveness of regional councils' pest management

Regional councils spend over \$41 million per year (2008 estimate) in managing weed and animal pests. This is a substantial sum so councils need better means of demonstrating that this expenditure is achieving the Long Term Council Community Plan (LTCCP) outcomes and represents good value to the community.

We held workshops with 12 regional and district councils to help biosecurity staff specify the desired outcomes from their pest management programmes and identify appropriate performance indicators and reporting mechanisms. We produced an online resource package that councils and other groups can use to maintain capability in this area. Uptake by councils has been significant: nine have already incorporated the principles in their pest management planning and the remainder intend to do so as appropriate to their reporting and review schedules.

This research is part of the Managing Invasive Weeds, Pests and Diseases portfolio, and was supported by Envirolink funding.

### Best practice in monitoring bird abundance

Landcare Research led an authoritative overview, with DOC and other agencies, of best practice and techniques for measuring abundance, occupancy and distribution of forest birds for national 'state of the DOC environment' monitoring. A pilot study measuring assemblages of widespread and common bird species at the national scale found that spatial variability in the landscape was a major factor influencing detection, an issue often overlooked when estimating bird population trends through time. Most endemic birds (i.e. those found only in New Zealand) were detected in forest, while most native and introduced species were detected in shrubland.

We used a monitoring study of bellbirds in Christchurch to gain greater understanding of issues affecting biodiversity in an urban situation. We can now offer advice and guidance on best practice for such monitoring schemes and how to modify green spaces to enhance urban bellbirds.

Two other studies showed that Australian magpies are not displacing native birds in rural landscapes. Magpies were continuously removed from five 900-ha sites for 3 years in one study and from individual farm gardens over a 6-week period in another, with no magpies removed in matched non-treatment sites. The studies indicated magpies had

little impact on native birds, a finding that has application for restoration ecology, conservation management, and biodiversity management on private land.

This research is part of the Managing Biodiversity portfolio. The projects were supported by ARGOS and Core funding, MBIE contestable funding, and Northland, Auckland, Waikato, Bay of Plenty, Hawke's Bay, Wellington, Marlborough, Canterbury and Southland regional councils.

### Predicting mast seeding for strategic predator control

Mast seeding is the occasional production of unusually high quantities of seed that occurs in some plants, such as beech trees. Masting events lead to irruptions in populations of seed consumers (mice and rats) followed by increased predator populations (e.g. stoats) that also prey on native birds and insects as well as rodents.

The theory that masting is triggered by warm temperatures the previous summer has been updated – with a new twist. With the University of Canterbury, we analysed 26 long-term New Zealand datasets spanning 15 diverse plant species, and 20 of the longest-running Northern Hemisphere datasets covering 17 species from North America, Japan and Europe. A wide range of mast-seeding species respond to the difference in temperature from one growing season to the next, i.e. the change in mean summer temperature between the two preceding years. This temperature-difference model is also a much better predictor of the rare phenomenon of consecutive high-seed events (double masts).

As well as being of international significance, the new model is of considerable importance to DOC as it more reliably predicts masting events more than a year in advance giving conservation managers time to plan and budget for pest control operations.

This research is part of the Managing Invasive Weeds, Pests and Diseases portfolio, and was supported by Core funding and MBIE contestable funding. [www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Invasive paper wasps

In New Zealand, two species of invasive paper wasps (*Polistes*) are a significant nuisance to humans, giving painful stings. Often their nests are found in residential gardens. Paper wasps are also voracious predators of native caterpillars and compete for nectar resources with native insects and birds. Currently, paper wasps are mostly found in the upper North Island, with limited distribution in the Hawke's Bay, Wellington, and top of the South Island. They have now established in Christchurch and Alexandra, and are likely to spread further in the next few decades.

Kate Ladley teaching survey techniques to DOC  
Southland Tier1 team Em Oyston, DOC

We combined specimen data from museums and our collections, public survey and previous information to model the extent of the wasps' likely distribution in New Zealand. We then integrated this information with knowledge on nest density and prey consumption to estimate the extent of biodiversity losses from different regions. We believe that paper wasp impacts in southern latitudes will be confined to a very short 'summer' period. Native insects that occupy grasslands and shrublands will consequently face additional predation risk.

This research is part of both the Managing Invasive Weeds, Pests and Diseases and Defining Land Biota portfolios, and was Core funded.

### Chemical pollutants found in wildlife

Some chemicals used for pest control, crop protection or in manufacturing have the potential to become persistent organic pollutants' (POPs) in the wider environment; at sufficient concentrations they may harm human health. Wildlife can act as sentinels for the presence of such contaminants, especially those that persist through the food chain. We tested fat samples from road-killed Australasian harriers, a native bird of prey. A variety of POPs were detected, mostly in relatively low concentrations. Potentially significant levels of compounds used as flame retardants were found as well as DDE, a metabolite of the organochlorine insecticide DDT. Liver samples from harriers and little blue penguins showed that some of the birds of both species had been exposed to anticoagulant rodenticides that are widely available 'off the shelf' in New Zealand. The long-term effects of such exposure are not known but urgently need further investigation given the continued use and apparently widespread environmental transfer of these rodenticides.

The Ministry for the Environment (MfE) monitors some POPs in humans, land and water; MPI monitors food for a range of chemical contaminants. Currently POPs and pesticide residues in wildlife, such as birds of prey, are not routinely monitored in New Zealand (as they are in the UK and some other countries). We will use these initial findings to help develop a national wildlife monitoring framework and to characterise contaminants that are known, emerging and potential threats to New Zealand biota and human health.

This research is part of the Managing Invasive Weeds, Pests and Diseases portfolio. The investigations were funded from various sources including Core funding and MBIE contestable funding.



### Biological control of heather

Heather (*Calluna vulgaris*) is a seriously invasive weed in the central North Island. The NZ Army supports our biocontrol programme but has also aerially applied the herbicide Pasture Kleen® (2,4-D ester). We compared the effectiveness and impacts of biocontrol with the army's use of herbicide.

Results showed that invading heather can be suppressed by either herbicide or heather beetle. Removal of heather by either method does lead to some invasion by exotic grasses, but we expect this will be short-lived. Herbicide application resulted in major non-target damage to broadleaved native plants. In contrast, there was no non-target damage from biocontrol, and the cover of native shrubs increased 4 years after the heather beetle had destroyed the weed. Also, once herbicide treatments ceased, heather reinvaded so repeat treatments would be needed in the absence of biological control.

This work provided DOC and the NZ Army with clear evidence that their long-term support for our heather biocontrol programme is justified, with clear benefits to indigenous biodiversity (compared to the previous use of herbicides).

This research is part of the Managing Invasive Weeds, Pests and Diseases portfolio, and was supported by Core funding, DOC and the NZ Army.



# LAND RESOURCES



## OUTCOME

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

Land resources include the soil's dynamic physical, chemical and biological 'systems', and the land cover, topography and hydrology. Land resources sustain primary production, ecosystem services (e.g., clean water, fertile soils) and the aesthetic benefits upon which New Zealand's economy, tourism, identity and brand are based.

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 for land use intensification and other development. Improving knowledge assets will enhance policy development for land use and resource allocation; improve the economic and environmental performance of primary sector; and support government in meeting

international reporting obligations. Our soils and land science capabilities are complemented by our informatics skills in accessing and analysing land information, and making it accessible in appropriate ways such as through mapping and geospatial visualisations.

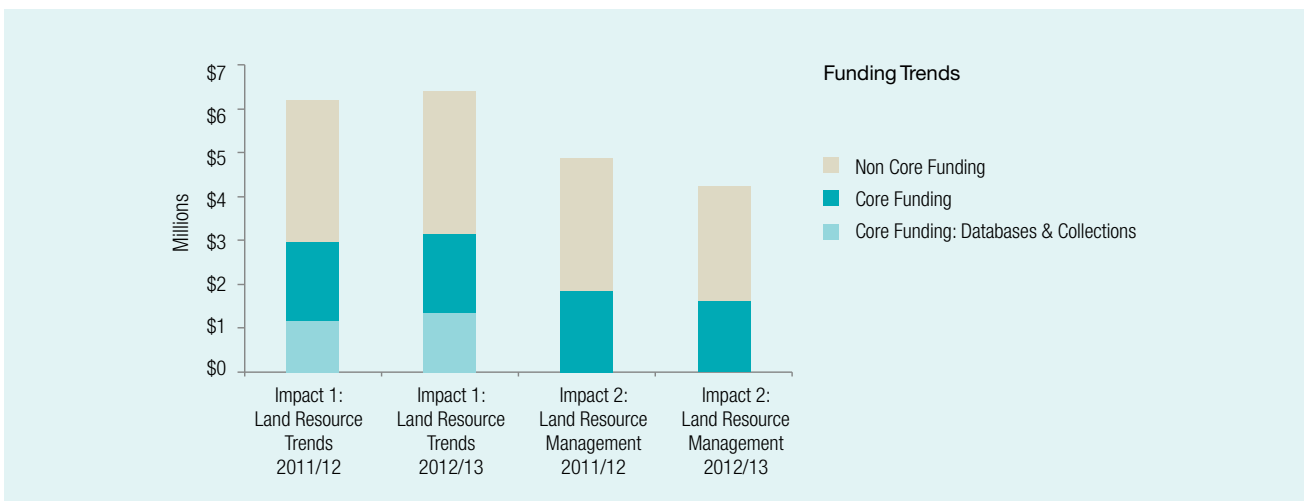
The Government's target of increasing exports from 30% to 40% of GDP will depend largely on research supporting a major lift in primary productivity. Such economic development opportunities must be achieved within environmental limits – through sustainable management of our land and water resources. The National Land Resource Centre (page 8) and the Productive Land Innovation Hub (the 'Lincoln Hub') (page 8) have critical roles to play in realising such opportunities and ensuring growth is 'green growth.'

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

<p><b>KPI:</b> LCDB (land cover), LUDB (land use), S-map (soil) and ESDB (ecosystem services) components of LRIS (Land Resource Information System) have been enriched and are being used under the New Zealand Government Open Access Licensing framework for web-services.</p> <p><b>2010/11 baseline situation:</b> Earlier versions of the land resource databases contained out-of-date information, with incomplete coverage for end-user needs, and with some barriers to open access.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>• S-map Online now provides users with detailed spatial information to help fine-tune land management and technologies.</li> <li>• Gisborne, Hawke's Bay and Southland councils now have access to significantly improved S-map coverage of soil variability.</li> <li>• An updated version of the Land Cover Database (LCDB), a thematic classification of land cover and land use (33 classes in LCDB v3.0), has been released.</li> <li>• Where appropriate, information from our nationally-significant databases is available online under an open-licensing agreement.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>• S-map coverage has been extended to include new areas in Waikato, Canterbury, Auckland and West Coast regions (page 18).</li> <li>• Data updates and access improvements to the Soils Portal, S-map Online and the Land Resource Information System (LRIS) dramatically increased usage (page 44).</li> <li>• LCDB has improved the accuracy of NZ's 5-yearly National Forest Resource Assessment for submission to the FAO (page 18).</li> <li>• End-users and stakeholders worked with us to finalise the roadmap for the future of LRIS and the Land Use Classification (LUC) system (page 8)</li> <li>• Stakeholders and end-users are working with us to develop LCDB4 (page 8)</li> <li>• Semi-automated processing of high resolution imagery is being used in large mapping projects for MfE – the Land Use Map (LUM) for carbon and the LCDB series for multiple applications (page 18).</li> </ul>
---	--	---

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

<p><b>KPI:</b> Regional councils and the irrigation, pastoral, horticultural and arable sectors are using knowledge of soil variability to improve the match between land-use practices and land capability.</p> <p><b>2010/11 baseline situation:</b> 'Ecosystem services' modelling and decision-making were not widely applied by regional councils, and soil variability was generally only recognised at the landscape scale.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>• Precision irrigation tuned to soil variability at the paddock scale achieved water savings of 20–36%, without any reduction in productivity, at three demonstration farms.</li> <li>• Soil variability underpins the design and storage capacity of effluent management systems that comply with DairyNZ's code of practice.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>• Decision makers, irrigators and developers of land on stony soils have new evidence quantifying the risk of nutrients, microbes and other contaminants leaching to groundwater (page 18).</li> <li>• Developers of the widely-used nutrient budgeting tool OVERSEER® will benefit from new data on soil properties and soil variability provided through S-map (page 18).</li> <li>• Complex spatial land-use models predict optimal land use in two case studies, and assess impacts of irrigation scenarios on groundwater nitrogen for the Waimea Plains (page 20).</li> <li>• Policy and planning to stabilise erosion-prone hill country benefit from modelling of future climate effects and new understanding of the 'non-timber' value of tree species for erosion mitigation (page 21).</li> </ul>
--	--	--



## Innovations

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

### S-map

Farmers and primary sector agencies need accurate on-farm and local-scale soils data for input into better water and nutrient management tools; local and central government need national-scale information to support policy and regulatory issues.

Smap Online coverage has been extended to include new areas in Gisborne, Waikato, Canterbury, Auckland, Bay of Plenty and the West Coast. We are collaborating with regional councils in Hawke's Bay, Canterbury, Waikato and Auckland to further extend S-map coverage and improve interoperability with the OVERSEER® model for setting nutrient limits and land use planning.

Further development of S-map is in train with others in the sector, and this collaboration will support best management practices on-farm, enhance accuracy of soils data in the OVERSEER® model, as well as help develop national standards and protocols for farm-scale soil mapping.

S-map is part of the Characterising Land Resources portfolio, and was supported by Core funding and regional councils.  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Stony soils

Despite demanding more water for productive use and being more prone to contaminant leaching, stony soils have become hotspots for land-use intensification. More information is urgently needed to assess the scale of the issue and to provide an evidence base supporting the development and implementation of appropriate land use policies. This year we undertook a national stocktake of the distribution, state of knowledge of, and agricultural development on New Zealand's stony soils. Of the stony soils in New Zealand, 53% occur in Canterbury, 12% in Otago, 9% in each of Southland and the West Coast, with the remainder are distributed across the Tasman, Marlborough, Hawke's Bay, Manawatu/Wanganui, and Wellington regions. Satellite images show that at least

196,000 ha of Canterbury's stony soils are now under irrigation. In addition, 42% of stony soils have low phosphorus (P) retention (<30%), 77% have moderate to rapid permeability, and 58% have low water storage capacity (30–90 mm). These attributes are all indicators of soils with high vulnerability to nutrient and microbial leaching.

We also carried out lysimeter experiments to assess leaching of P, carbon (C), nitrogen (N), and microbes (*E. coli*) under a dairy development scenario on stony and very stony Canterbury soils. Initially we found large quantities of C and N in the leachate, and smaller but increasing levels of P. There was high *E. coli* leaching through very stony soils. Microbial leaching increased in some stony soils following hoof pugging. This work indicates that shallow groundwater may be vulnerable to nutrient and microbial contamination under some land-management practices on stony soils, especially where stones are close to the surface with a sandy soil matrix.

This research is part of both the Characterising Land Resources and Realising Land's Potential portfolios, and was supported by Core funding and regional councils.  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Remote sensing and data processing for mapping

New methodologies have been developed to increase the efficiency of map revision for MfE's national Land Use Map (LUM). It will also be used in the upcoming Land Cover Database (LCDB4) project that provides very high-accuracy, national-scale imagery and databases for environmental management, spatial planning, economic modelling, to name just a few applications. When averaged across all of New Zealand and all classes, analysis of the third edition of LCDB (released June 2012) shows that we are achieving accuracies in excess of 96%. For the much smaller set of polygons that represent actual change between 2001 and 2008, the LCDB detects them with an accuracy in excess of 90%. The LUM is primarily used for national carbon reporting while the LCDB has a wide range of applications, including biodiversity monitoring, National Forest Resource Assessment reporting, and more accurate targeting of possum control operations (e.g., by AHB/TBfree New Zealand). The new methodologies have also been used to analyse changing land use patterns in central Canterbury, with a paddock-scale project demonstrating the value of an automated approach to regional councils.

This research is part of the Characterising Land Resources portfolio, and was supported by Core funding and MBIE contestable funding.



### Soil biodiversity hotspots in Antarctica

Despite the extreme conditions, bacteria are distributed throughout soils of Antarctica and represent a major and important part of the biodiversity and ecosystem processes. The spatial distribution and composition of these microbial communities are strongly influenced by many soil attributes such as water content, salinity, organic carbon and pH.

Researchers combined field data from extensive soil sampling in Antarctica's Dry Valleys and Environmental Chemistry Laboratory analyses of >500 samples with digital soil mapping techniques. From this, they were able to produce maps showing microbial habitats and biodiversity hotspots with very good spatial resolution (30 metres).

This represents a significant breakthrough in mapping microbial biodiversity in Antarctica's vast, inaccessible and inhospitable landscape. Mapping microbial biodiversity is a prerequisite to monitoring impacts of climate change and to further studies of terrestrial Antarctic ecosystems.

The innovative approach was very well received when presented at a recent workshop to mark the inauguration of the New Zealand Antarctic Research Institute (NZARI), a charitable trust involving most Antarctic researchers in New Zealand.

This research is part of the Characterising Land Resources portfolio, and was supported by MBIE contestable funding with logistical support from Antarctic New Zealand.

### Antarctic soil vulnerability mapping

In the process of mapping the soils of Wright Valley, Antarctica, we developed a rapid method to determine (and hence map) soil vulnerability to human foot traffic. The research was used to inform discussions on soil vulnerability in the Dry Valleys at the CEP Antarctic Treaty Consultative Meeting in Brussels. The map will also aid the selection of walking routes, helicopter landing sites and campsites used by visitors – activities that can have very significant, long-term impacts on the fragile soils. Mapping has continued in the Victoria and Alatna valleys, Convoy Range, and Coombs and Alan hills.

This research is part of the Characterising Land Resources portfolio, and was supported by MBIE contestable funding with logistical support from Antarctic New Zealand.

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

### Land use change and ecosystem services

A decade of accelerating land-use change and intensification has benefitted the economy but the consequences for ecosystem services are poorly understood. Land use intensification is a complex process to model as it involves manipulation of stock, plant species, disturbance, nutrients, and water. Worldwide, there is no agreed terminology, with many different definitions and surprisingly diverse metrics to describe land use. In addition, these components are integrated in complex ways along gradients of land use intensification.

To ensure greater objectivity and robustness, we first reviewed published information then developed a new framework and standardised terminology for land use intensification. This framework will enable consistent quantification of current land-use intensity, and enable comparisons of the effects of ongoing intensification on ecosystem services across land-cover classes. More generally, this research underpins the ability to report on status and trends of land resources and ecosystem services by developing comparable measurements across sectors and land uses.

We then developed a holistic model that assesses the impacts of land use change on all ecosystem services for all sections of the community. As such, it could be used to assess sustainable development and equity in resource use. Detail is provided at the level that policy and management decisions are made. Spatially explicit indicators cover important services for New Zealand – regulation of climate, control of soil erosion, regulation of water flow (quantity), provision of clean water (quality), provision of food and fibre, and provision of natural habitat.

In one scenario, we used the model to assess potential trade-offs between biodiversity and the non-biodiversity goals (e.g. reduced soil erosion, nitrogen retention, and fewer greenhouse gas emissions) derived from restoration projects. If restoration projects are prioritised based on non-biodiversity or multi-objective goals, biodiversity gains are likely to be compromised (especially compared with projects prioritised on biodiversity goals only).

This research is part of the Understanding Ecosystem Services and Limits portfolio, and was supported by Core funding.

### A Land Use Management Support System

Sustainable land management depends on a deep understanding of the spatial variability of ecosystem properties and processes, and how they are affected by human activities. We developed the Land-Use Management Support System (LUMASS) to help planners assess the environmental impact of land use and decide where a particular land use might best occur (or should not occur) and identify appropriate new opportunities to provide greatest benefit to the well-being of people and the environment. In situations where there are multiple and possibly conflicting stakeholder objectives and constraints, LUMASS can identify optimal land use and critically assess the environmental limits within which compromises or trade-offs need to be found.

In case studies in the Waitaki catchment (South Island), the central North Island, and Hawke's Bay, we used LUMASS to demonstrate how optimised land use could improve ecosystem services while maintaining agricultural production.

This research is part of both the Enhancing Policy Development and Characterising Land Resources portfolios, and was supported by Core and Envirolink funding.

### Improving policies to protect groundwater

Where land–water policy reforms dictate significant changes to existing agricultural practices, regional councils and industry groups need to demonstrate that the changes are based on robust scientific evidence. We are providing key components of the evidence base. In the first project, we continued working with ECan to review modelled values of nutrient losses, and application of these values in setting nutrient discharge allowances and in estimating total loads in a catchment. We assessed the suitability of the Land Use Capability Classification (LUC) as a proxy for setting nutrient limits according to the natural capital of the land (as described in Horizons Regional Council's One Plan). We suggested some modifications to the One Plan approach to better allow for irrigation in the drier Canterbury conditions. We also developed a new, spatially more accurate, model of LUC that is suitable for the flatter parts of Canterbury, based on S-map information.

In a second project, we showed how different ways of entering soils information affected results from the OVERSEER® Nutrient Budgets model. This highlighted some issues for the OVERSEER® development team to consider, and marks the beginning of a new collaboration between S-map and OVERSEER®.

This research is part of the Characterising Land Resources portfolio, and was supported by Core funding and ECan.

### Reducing farm runoff into Lake Taupō

Water quality is deteriorating in the once pristine Lake Taupō (Taupō-nui-a-Tia). Each year, the lake receives about 1250 tonnes of nitrogen (N), 30–40% of which is leached from pastoral farmland. The Waikato Regional Council aims to reduce manageable N entering the lake by 20%. This target is challenging and farmers are now looking for economically viable, low-N-loss alternative land use options. The Lake Taupō Protection Trust commissioned a 3-year field research project to quantify N-leaching under cut-and-carry lucerne and other land management regimes. Our large-scale soil lysimeter array near Lake Taupō is pivotal to this work.

This research is part of both the Understanding Ecosystem Services and Limits and Realising Land's Potential portfolios, and was supported by the Lake Taupō Protection Trust.

### Irrigation proposals in Tasman District

The results of two complex modelling projects will be used by Tasman District Council to guide water allocation. In the first project (with GNS Science), we showed that proposed increases in irrigation for the upper Motueka River catchment could be feasible. We modelled interactions between groundwater and river water levels across six development scenarios. This indicated that new groundwater abstraction in the lower reaches could occur, in addition to existing abstraction, without breaching the river's low-flow limits during the irrigation season.

The second project (with Plant & Food Research and the Cawthron Institute) assessed nutrient contamination risks to groundwater from the proposed Waimea Water Augmentation Project. Full irrigation across the Waimea Plains could potentially increase nitrogen (N)-concentrations entering groundwater by 23%, and hypothetically by up to 50% if the entire plains were irrigated for market gardening.

However, the increased irrigation would dilute and disperse N within the multiple aquifers so at most, only about half the total load would reach sensitive down-gradient receiving waters such as springs and the lower river. When the augmentation scheme is operating with water being released from the dam, river water quality is likely to improve.

Both projects made several recommendations for best-practice land and water management to further protect the various water bodies.

This research is part of both the Understanding Ecosystem Services and Limits and Realising Land's Potential portfolios. The first project was supported by MBIE and Tasman District Council, and the second one by MPI and the Waimea Water Augmentation Committee.

### Managing future erosion risk

We identified areas of New Zealand that would be most susceptible to erosion under future climate change, and the potential impacts of climate on erosion control. Annual rainfall is predicted to increase in the west and south of the country and decrease in the east and north (with more frequent extreme events). By 2080–2099, most places are projected to experience nearly twice as many 24-hour extreme rainfall events with a 100-year return period than occurs at present. Increased windiness and incidence of drought are predicted, particularly in the east. This project was collaborative with NIWA, GNS Science, AgResearch, Plant & Food Research and Scion.

Ongoing work with Scion investigated how trees and forests affect erosion and how forest management can minimise or mitigate erosion. Around 45% of New Zealand's 1.8 million ha forest estate is first-rotation *Pinus radiata*, much of which was planted on steep terrain for erosion control. During harvesting of these forests, now and over the next 10–15 years, forest owners must manage landslide risk and the offsite movement of logging debris. Logged areas will need to be replanted, with consideration given to non-timber benefits such as 'erosion mitigation'.

This research is part of the Realising Land's Potential portfolio, and was supported by MBIE contestable funding and MPI funding via subcontracts from Scion and Future Forests.

Severe erosion in southern Hawkes Bay following a major storm in 2011 Les Basher





# GREENHOUSE GASES



## OUTCOME

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

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

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

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

Research is needed to improve methodologies for measuring soil carbon storage and for reducing uncertainty in estimating and scaling emissions, and quantifying changes in emissions as a consequence of key land-use and management change. This allows 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.

<p><b>Impact 1:</b> 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.</p>		
<p><b>KPI:</b> MPI and MfE are using verified estimates of greenhouse gas (GHG) emissions and carbon storage to reduce uncertainty in national inventories.</p> <p><i>2010/11 baseline situation:</i> Estimates of greenhouse gas emissions, and how these change with altered land use, contained many uncertainties.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>Afforestation was greater than deforestation (579,000 ha ± 2% and 75,000 ha ± 6% respectively) in New Zealand between 1990 and 2008. The difference gave MPI an estimate of carbon emissions due to forest changes.</li> <li>Modelling the growth of pine stands and kākūka/mānuka stands is providing MPI with carbon sequestration rates and how these vary regionally and temporally.</li> <li>The uncertainty in estimating soil carbon for perennial croplands in MfE's Soil Carbon Monitoring System has been significantly reduced.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>Greater certainty in New Zealand's national GHG inventory has been achieved through more accurate measurements of N<sub>2</sub>O from pastoral hill country, and updated emission factors; these N<sub>2</sub>O emissions are less than previously reported (page 24).</li> <li>MfE has greater confidence in carbon estimates from the LUCAS plot network and understand the accuracy of carbon change that can be detected (page 25).</li> <li>MfE has improved information on the impact of erosion on soil carbon stocks and the need to incorporate the effect of erosion into the Soil Carbon Monitoring System (page 25).</li> </ul>
<p><b>Impact 2:</b> Strategies for land use and asset management increase carbon storage, mitigate greenhouse gas emissions and balance environmental, economic and social benefits</p>		
<p><b>KPI:</b> Agricultural land managers and DOC are, where appropriate, using validated methodologies and land-use practices to mitigate greenhouse gas emissions and increase carbon storage and adapt to likely climate change effects.</p> <p><i>2010/11 baseline situation:</i> Models of carbon dynamics were largely inadequate for understanding wider implications of land use.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>The effectiveness of the nitrification inhibitor DCD in reducing nitrous oxide emissions from stock effluent can be optimised for use by agricultural land managers.</li> <li>Land managers have an improved basis for incorporating variability in carbon stocks when planning emissions management for natural forests.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>Land management strategies and the National Greenhouse Gas Inventory benefit from new data on the long-term relative warming and cumulative effects of CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> emissions attributed to land use change (page 25).</li> <li>The agricultural sector has updated-information on the effectiveness of the urease inhibitor Agrotain® in reducing NH<sub>3</sub> emissions (page 26).</li> <li>National-scale indirect measures of the likelihood of, and average time taken for, gorse or broom to become 'forest land' could enhance assessment of eligibility for entry into the Emissions Trading Scheme (page 27).</li> </ul>



## Innovations

**Impact 1 (Trends):** *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.*

### Reassessing Global Warming Potentials

All greenhouse gases contribute to global warming, but they absorb infrared radiation to different degrees and have different longevities in the atmosphere. The relative Global Warming Potentials (GWPs) of different gases are currently calculated in a fairly simplistic way by calculating the radiation absorption of each gas over a specified time horizon, most typically 100 years, but are not explicitly linked to an assessment of ultimate climate-change impacts.

We have developed a new metric, the Climate Change Impact Potential (CCIP) that derives a quantitative assessment of the importance of each gas according to its impact related directly to temperature increases, which related to the rate of warming, and to cumulative warming.

In principle, CCIPs are a better metric than GWPs in accounting for the climate-change impact of different greenhouse gases and the effect of their release or uptake at different times. Compared with GWPs, calculated CCIPs would shift the emphasis from short lived methane (CH<sub>4</sub>) to long-lived nitrous oxide (N<sub>2</sub>O). It would have only a small effect on New Zealand's overall greenhouse gas emissions, just shifting the relative emphasis from CH<sub>4</sub> to N<sub>2</sub>O.

The new approach was well-received when presented at a recent International Energy Agency meeting in Vienna, with participants interested in obtaining details of the methodology and its implications. Improved understanding and metrics for greenhouse gases will provide better estimates of the impact resulting from greenhouse gas emissions, enabling governments to better target mitigation efforts at those gases that would have the greatest effect in reducing ultimate climate change impacts.

This research is part of the Measuring Greenhouse Gases and Carbon Storage portfolio, and is supported by Core funding.

### More accurate emission factors

We developed emission factor (EF) look-up tables for calculating the direct nitrous oxide (N<sub>2</sub>O) emissions from grazed pasture soils in New Zealand. Look-up tables of long-term average direct EFs (and their associated uncertainties) were generated using multiple simulations of a new model over a representative range of major soil, climate and management conditions occurring in New Zealand, using 20 years of climate data. These EFs were then combined with national activity data maps to estimate direct N<sub>2</sub>O emissions from grazed pasture in New Zealand. This information will be used for modeling the impacts of land use changes and for refining the New Zealand Greenhouse Gas Inventory to be more regionally specific.

Our NZ-DNDC model has been also able to simulate N<sub>2</sub>O reductions from nitrification inhibitor-treated grazed pasture, showing that the model is able to account for the mitigation technology.

Excreta from livestock are another significant source of N<sub>2</sub>O emissions. Our previous research in collaboration with AgResearch indicated the currently-used EF could be lowered. Recently we showed that applying this lower EF to beef, deer and sheep farming on rolling and steep slopes could result in ~37% lower N<sub>2</sub>O emissions than indicated by the current inventory values. If the lower EFs for sheep urine and dung on lower slopes are also included, emissions for hill country could be up to 61% lower than the emissions currently reported in New Zealand's Greenhouse Gas Inventory.

Ammonia (NH<sub>3</sub>) volatilisation represents a significant loss of nitrogen from agricultural systems and is a precursor for N<sub>2</sub>O formation; hence NH<sub>3</sub> included in national inventories. In research commissioned by MPI, field measurements of NH<sub>3</sub> emissions from cattle excreta in-situ confirmed the New Zealand specific EF (used since 2008) is indeed appropriate.

All these areas of research contribute to improving the accuracy of reporting N<sub>2</sub>O emissions in the National Inventory and support MPI with policy decisions and international obligations.

This research is part of the Measuring Greenhouse Gases and Carbon Storage portfolio, and was supported by Core funding. MPI and a MPI subcontract through AgResearch, and Ballance Agri-Nutrients.



### Land Use and Carbon Analysis System (LUCAS)

We performed the first New Zealand national-scale assessment of the uncertainty associated with plot-based estimates of forest carbon (e.g. error associated with measuring tree heights, diameters, and the models used to scale these individual tree measurements into plot and then national-scale carbon estimates). Above-ground carbon stock estimates were 1.7% higher with error propagation than without, and had 2.7% greater uncertainty. Carbon change estimates were more sensitive to measurement and model uncertainty, with a 39% increase in uncertainty. Our findings show that national-scale plot-based estimates of carbon stock and carbon change are relatively robust to measurement error and model uncertainty but that carbon stock change between two measurement periods needs to be larger than we previously thought in order to detect it.

MfE has commissioned us to run our uncertainty estimation alongside the national calculations of Kyoto Protocol Commitment Period 1 carbon stock change for natural forests.

This meets the recommendations of the UNFCCC Good Practice Guidance and will be the first time this type of uncertainty has been provided in New Zealand reports to the UNFCCC. MfE can have increased confidence that the carbon estimates from the existing LUCAS (Land Use and Carbon Analysis System) plot network have relatively little bias and they know the size of stock change they can confidently detect.

This research is part of both the Measuring Greenhouse Gases and Carbon Storage and Measuring Biodiversity Change portfolios, and was supported by Core funding and MfE.  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Innovative new approach to assessing soil carbon

We refined traditional methods of assessing organic carbon stocks in soil and how they vary across a landscape. The project compared two digital soil mapping strategies for a large arable field. The first method used conventional laboratory analysis of soil samples collected from across the field. These point data were combined with electromagnetic survey data to model the field. The second strategy used visible near infra-red spectroscopy (VNIR) to estimate carbon stocks across the same field. VNIR Spectroscopy proved to be very accurate and is potentially a much more cost-efficient approach to mapping the spatial variability of soil carbon as fewer laboratory analyses are required.

This research was part of the Characterising Land Resources portfolio, and was supported by Core funding.

### Impact of erosion on soil carbon

Research into the effects of landslide, gully and earthflow erosion on soil carbon stocks found that, while gully erosion has a very minor impact, both landslides and earthflows have significant effects. The loss of carbon due to erosion is large (30 tonnes C/ha) compared with the changes in soil carbon stocks associated with land use change.

This work could benefit the Soil Carbon Monitoring System (CMS), which currently does not account for erosion. Our results highlight the importance of erosion – at least for baseline 1990 soil carbon stocks for New Zealand. It remains to be established whether erosion is significant to post-1990 soil C stock changes.

This research is part of the Realising Land's Potential portfolio, and was supported by MPI funding.

**Impact 2 (Management):** *Land-use options, asset management and other methods that increase carbon storage and mitigate greenhouse gas emissions are understood and balanced for environmental, economic and social benefits.*

### Impacts of land use change on greenhouse gas inventories

Land use change between forestry and agriculture can generate high levels of net carbon dioxide (CO<sub>2</sub>) emissions, which obviously has important implications for New Zealand's long-term greenhouse gas inventories and economic liabilities. Reforestation of pastoral land can regain former carbon stocks, but the rate of carbon sequestration is much slower than the rate of carbon loss from deforestation.

Recent research also found that nitrous oxide (N<sub>2</sub>O) and methane (CH<sub>4</sub>) emissions from grazed pastures and ruminant livestock are much higher than from forests. However because of the shorter atmospheric 'lifespan' of CH<sub>4</sub>, emissions from converted pasture accumulate for only a few decades before concentrations reach a new equilibrium.

N<sub>2</sub>O has much greater longevity in the atmosphere – concentrations accumulate nearly linearly for many decades. This means the true impact of converting forestry to pastoral agriculture will continue far into the future.

But pastoral grassland soils in New Zealand could become a greater carbon sink. Our analysis of 10 years' research data on the impact of elevated atmospheric CO<sub>2</sub>

concentrations clearly show that even when atmospheric CO<sub>2</sub> concentrations reach 475 ppm (perhaps in 30 years), CO<sub>2</sub> fertilisation will have very significant effects on some key soil properties, including soil carbon and nitrogen levels. Such increases in soil carbon indicate a potential to mitigate carbon emissions.

Policymakers, when using this new information in combination with climate warming data, will be better able to anticipate changes needed in future pasture management across different parts of New Zealand.

This research is part of the Measuring Greenhouse Gases and Carbon Storage portfolio, and was supported by Core funding.

### Continuous, *in-situ*, measurements of agricultural greenhouse gases

We have established a long-term research site on a newly converted, irrigated dairy farm (Synlait's Beacon Farm) on the mid-Canterbury plains. We installed automated systems to continuously measure concentrations of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O at identical irrigated and un-irrigated pasture sites, providing a time series of the fluxes of all three greenhouse gases. We also take continuous measurements of environmental variables that control greenhouse gas exchange, including pasture height, soil temperature, soil moisture and irrigation events. Pasture production and the amount of carbon removed by grazing are being quantified. As all these measurements continue, they will build our understanding and will allow us and Synlait to assess the effects of management changes and climate on the annual greenhouse gas budgets of an intensely managed dairy farm. Initial measurements have highlighted that after each grazing event, the pasture is a net source of CO<sub>2</sub> for about 7 days, and becomes a progressively stronger sink during the next 2 weeks before the next grazing event.

We are collaborating with Lincoln University and the University of Canterbury to enable two studies of small-scale soil processes driving greenhouse gas fluxes. These projects, at Beacon Farm, are focusing on the conditions controlling N<sub>2</sub>O production and on relationships between above- and belowground CO<sub>2</sub> fluxes.

This research is part of the Measuring Greenhouse Gases and Carbon Storage portfolio, and is supported by Core funding with considerable in-kind support from Synlait Farms Ltd.

### Urease inhibitors

Ammonia (NH<sub>3</sub>) is a precursor to the formation of N<sub>2</sub>O. In research for Ballance Agri-Nutrients, we found that applying the urease inhibitor Agrotain® with urea fertiliser

or applying irrigation (or rainfall) could significantly reduce NH<sub>3</sub> emissions and improve fertiliser N-use efficiency in grazed pastoral systems. This enabled us to adjust and recommend values for NH<sub>3</sub> emission factors for pastoral soils fertilised with Agrotain® treated urea. These recommendations have been adopted.

This research is part of the Measuring Greenhouse Gases and Carbon Storage portfolio, and was supported by Ballance Agri-Nutrients.

### Methane biofiltration technology

We developed a biofilter capable of removing most of the methane (CH<sub>4</sub>) produced from dairy farm effluent ponds. Active CH<sub>4</sub>-eating bacteria (methanotrophs) in the biofilter convert the CH<sub>4</sub> into biomass and some CO<sub>2</sub>; NH<sub>3</sub> is also consumed. Earlier research identified a volcanic soil that contained a very active population of methanotrophs. *In vitro* experiments showed that a biofilter made from this soil could potentially remove almost all of the CH<sub>4</sub> from an average dairy farm waste pond. Our first prototype CH<sub>4</sub> biofilter has been consuming >95% of the CH<sub>4</sub> in biogas from under a cover on an effluent pond at Massey University No. 4 dairy farm for about 3 years with minimal maintenance. We recently developed and successfully lab-tested a second biofilter, similar in efficiency to the first prototype, that will now be tested as part of a floating pond cover on a commercial dairy farm.

Interest in our CH<sub>4</sub> biofilter has been shown by the UK and Spain, particularly for removing CH<sub>4</sub> and NH<sub>3</sub> emissions from livestock waste in a range of agricultural systems and regions.

This research is part of the Realising Land's Potential portfolio, and was supported by Core funding and MPI funding.

### Mapping gorse and broom as 'forest'

Both MfE and MPI need to know how much of New Zealand's vegetation qualifies as either pre1990 or post1989 'forest land'. Gorse and broom form a nurse canopy for indigenous trees that qualify as 'forest trees'. In places where the succession is allowed to proceed to tall forest, the land is deemed forest land when there is a sufficient density of tree species that can reach 5m height at maturity with crown cover of at least 30% of each hectare. Because direct detection of trees is problematic, especially if they are underneath a gorse or broom canopy, we used national scale indirect measures of likelihood that a given area of gorse or broom will become forest and the average length of time this takes. This research will be used by MPI to determine whether applicants to the Emissions Trading Scheme (ETS) or Permanent Forest Sink

Initiative (PFSI) have eligible forest land (or whether they have a deforestation liability). It also will be used to inform the development of new ETS lookup tables that take into account the initial lag phase between establishment of woody shrubs and establishment of tall forest.

This research is part of both the Managing Biodiversity Change and Measuring Greenhouse Gases and Carbon Storage portfolios, and was supported by MPI funding.

### Carbon farming on Māori land

Māori land has been widely touted as being suitable for carbon sequestration, which led to strong interest from iwi in potential carbon farming enterprise. We investigated the extent and nature of Māori land resources at a national scale to gain broad understanding of land types, land capability, total carbon stocks and the potential for carbon sequestration. Results show there is considerably less Māori freehold land available for carbon sequestration under 'Kyoto forest' criteria. Instead of the one million hectares as previously talked about, only 482 000 ha meet Kyoto forest eligibility criteria; of this land, only 122 800 ha fit the definition of 'undeveloped'. This undeveloped marginal land should be targeted by more effective policy and programmes, conducive to Māori aspirations and values, to promote forestry and protective vegetative cover on this fragile erosion-prone land.

Carbon sequestration remains a real opportunity on Māori land if schemes are aligned with Māori aspirations rather than Government and international agendas.

This research is part of both the Characterising Land's Resources and Measuring Greenhouse Gases and Carbon Storage portfolios, and supported by Core funding, MBIE contestable funding and MPI funding.

### Soil respiration and carbon sinks under tussock grasslands

Soil respiration plays a critical role in the regulation of carbon cycling at ecosystem and global scales, and is approximately 10-times our current anthropogenic carbon dioxide (CO<sub>2</sub>) emissions. The response of soil to rising temperatures is still currently debated, with some models suggesting that soils will become a net source rather than a sink of CO<sub>2</sub>. Other models suggest that an increased carbon sink in the soil, due to rising temperature, will offset the effects of increased CO<sub>2</sub>.

Understanding the processes regulating the temperature response of soil respiration is complex because there are two distinct components to soil respiration. First, respiration of roots and associated microbes causes rapid turnover

of carbon in the system. Second, decomposition of soil organic matter and litter represents slower turnover of much larger carbon pools. Current models of carbon cycling assume both components behave the same way as the soil warms but the models would be affected profoundly by small variations in the rate of soil organic matter turnover between the two components.

Using a novel approach, we found the temperature response of soil respiration in tussock grasslands primarily relates to root respiration, while soil warming has little effect on turnover of soil carbon.

This will improve our ability to predict the impact of soil warming on ecosystem carbon dynamics. This finding will not only contribute to more accurate global models of climate change, it will also improve New Zealand's understanding of the likely impacts of a changing climate on our important soil resources.

This research is part of the Measuring Greenhouse Gases and Carbon Storage Portfolios, and was supported by Core funding.

Native trees growing up through flowering gorse.  
Most of the land in this picture would qualify as 'forest'.  
Lary Burrows





# DEVELOPMENT WITHIN ENVIRONMENTAL LIMITS



## OUTCOME

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

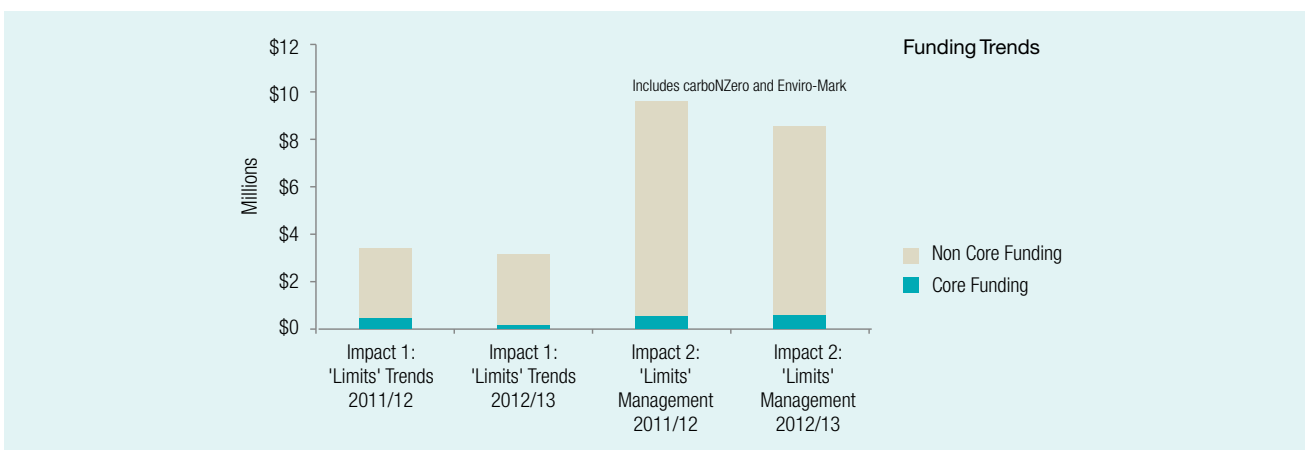
To achieve sustainable economic development, New Zealand must work within environmental limits and be responsive to the often-diverse and conflicting needs of multiple stakeholders, including overseas markets. Progress has been made nationally in developing multi-stakeholder, collaborative processes for the future management of freshwater within limits (especially quality and allocation). But overseas customers of our food and beverage products increasingly associate human health with environmental health and expect high levels of assurance in the production process. Businesses operating in New Zealand are recognising the need for 'social licence to operate' – a concept that reflects a reciprocal relationship between business and the community and demands a level of transparency and performance from business.

Our research underpins effective environmental policy and provides the framework for sound resource management decisions spanning urban, rural and conservation

landscapes and catchments, the full range of ecosystem services and natural resources. Policy development processes are enhanced through (1) engagement across a wide range of stakeholders to understand preferences, values and governance options; (2) scientific information to support choices and decisions; and (3) adaptive management to evaluate and improve policy performance.

Our environmental certification products and services (page 48) contribute to the management, transparency and reputation needs of hundreds of New Zealand and overseas businesses. In some cases the issues are subject to trade regulations. For example, managing possums and associated bovine TB is a significant trade compliance issue for New Zealand's meat industry. Our research supports TBfree New Zealand (previously AHB) in its mission to eventually eradicate the disease entirely and increase New Zealand's competitiveness in overseas food markets.

<p><b>Impact 1:</b> Approaches to resolving complex environmental issues are understood, and opportunities recognised for adapting to global change and reducing vulnerability to resource scarcity.</p>		
<p><b>KPI:</b> Industry sectors, central and local government are making strategic use of research findings, associated indicators of performance, and new economic instruments to respond to complex environmental issues, global change processes and resource scarcity.</p> <p><b>2010/11 baseline situation:</b> Diverse stakeholders were in a variety of conflicts over the management of natural resources (e.g. water, biodiversity) with differing values and expectations.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>The energy sector (Meridian Energy, Solid Energy and Buller Coal) is incorporating offset programmes and fit-for-purpose rehabilitation activities into the companies' environmental management.</li> <li>The New Zealand Forest and Agricultural Regional Model (NZFARM) is being used to assess policy options for improving water quality and the economic impacts for meeting environmental limits.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>The energy and mining sectors continued to incorporate offset programmes, land rehabilitation planning, research and advice into their environmental management (page 30).</li> <li>ECan, MfE and other stakeholders used our NZFARM economic modelling tool in two Canterbury catchments as part of their collaborative process for setting water limits (page 30).</li> <li>Waikato, Hawke's Bay and Canterbury regional councils are using our participatory research in setting water limits; three other councils are considering adopting these processes within their regions (page 31).</li> </ul>
<p><b>Impact 2:</b> Integrated economic, social, cultural and environmental initiatives for business and industry are effective in maintaining or enhancing their international competitiveness, market access and social licence to operate</p>		
<p><b>KPI:</b> An industry sector (dairy, horticulture or energy) is using a framework for integrating economic, environmental, social and/or cultural drivers to meet community and/or market requirements.</p> <p><b>2010/11 baseline situation:</b> Industries were beginning to use more sophisticated frameworks such as environmental footprinting (e.g. carbon and water) to support reputation and brand.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>The World Resources Institute's 'ecosystem service review' methodology was applied to develop strategies for ZESPRI International to manage risks and opportunities arising from growers' dependence on ecosystems.</li> <li>Our carboNZero<sup>Cert</sup>™ programme and CEMARS® is being used by &gt;130 New Zealand businesses and organisations.</li> <li>Our Enviro-Mark® management system is being used by &gt;170 member firms in the print, food production, and retail industries.</li> <li>A strategy for harvesting brushtail possum fur, while meeting forest conservation outcomes, was developed with a rural Tūhoe community.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>New Zealand's biosecurity and overseas market access is supported by a DNA-barcoding tool for accurate, rapid identification of <i>Colletotrichum</i>, a major group of plant pathogenic fungi (page 32).</li> <li>134 New Zealand organisations are registered in CEMARS or the carboNZero programme. To date carboNZero Holdings has undertaken over 95% of all the voluntary accredited greenhouse gas certifications across Australia and New Zealand (page 48).</li> <li>Our Enviro-Mark® management system is being used by 175 member firms in the print, food production, and retail industries, 65% of which are at or above Gold certification level (page 48).</li> </ul>
<p><b>KPI:</b> Bovine TB is eradicated by the AHB from vector populations in two extensive forest areas in programmes responding to economic, social, cultural and environmental drivers.</p> <p><b>2010/11 baseline situation:</b> TB persisted in parts of New Zealand, including a few significant areas where possums and deer are the main wildlife hosts.</p>	<p><b>Progress 2011/12:</b></p> <ul style="list-style-type: none"> <li>A quantitative framework has been developed for objectively assessing the probability that bovine TB has been eradicated from a specific forest area. The framework increases the cost-effectiveness of eradication efforts by ensuring control measures are not stopped too soon or continued for longer than necessary.</li> </ul>	<p><b>Progress 2012/13:</b></p> <ul style="list-style-type: none"> <li>Using our framework, AHB declared TB had been eradicated from wildlife vectors over 400 000 ha. The TB programme is comfortably on track to meet or exceed its eradication targets (page 48).</li> <li>Significantly-reduced costs of aerial pest control operations is enabling TBfree New Zealand, DOC and NGOs to extend coverage to new areas, to achieve both biodiversity and TB benefits (page 33).</li> </ul>



## Innovations

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

### NZ-FARM

Farmers are increasingly faced with multiple environmental constraints. We designed the NZ-FARM (NZ Forest and Agricultural Regional Model) to help farmers and agencies assess the impacts of changes in land use, agricultural output, farm management, environmental impacts and climate and water policies on farm incomes. It is particularly useful for regions (such as Canterbury for the Selwyn-Waihora and Hinds water management zones) undertaking processes to set nutrient limits where agricultural production is expected to expand or intensify.

We used NZ-FARM to assess the economic impacts of climate and water policies in the Hurunui and Waiau catchments in North Canterbury. This showed a nutrient reduction target of 25% below baseline levels could be achieved (plus noticeable reductions in greenhouse gas emissions from farming activities) with relatively modest declines in total net revenue.

The integrated nutrient–greenhouse gas policy had less impact on farm income and produced greater environmental benefits than just charging greenhouse gas emissions at \$12.50 per tCO<sub>2</sub>e. Simultaneously imposing both a nutrient reduction policy and greenhouse gas price of \$25 per tCO<sub>2</sub>e could significantly cut greenhouse gas emissions although it would not reduce nutrient loads much beyond the stand-alone policy, and net income for farmers would drop by 17%.

This research is part of the Enhancing Policy Development portfolio. Development of this model has been supported by MBIE and MPI with analysis supported by MfE, ECan and MPI.  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Survey of Rural Decision Makers

Scientists and governments are increasingly looking for ways to understand the complexity and outcomes of interactions between human agents and their environment,

particularly with regard to the impact of agricultural practices on the environment. To strengthen modelling for the rural sector, we collected data from 528 farmers, foresters, and growers in Canterbury, Southland, and Waikato. Topics included demographics; farm/forest/growing operation characteristics; succession plans; risk tolerance; profitability; information sources; objectives; management practices; intentions; perceived behavioural control; subjective norms; and environmental attitudes. On 1 July 2013, the survey was also rolled out to the other regions.

The 'real-life, on-the-ground data' feed into spatially-explicit economic models such as our Agent-based Rural Land Use New Zealand (ARLUNZ), which helps forecast land use effects resulting from changes in social networks and decision-making, and NZ-FARM. In addition, the survey data are intrinsically useful and interesting, and the survey has prompted discussions regarding further work with two councils.

This research is part of the Enhancing Policy Development portfolio. The 'Survey of Rural Decision Makers' was designed jointly by Landcare Research and AgResearch with input from MfE, MPI and DairyNZ; it is part of a wider programme of work that will enable the developers of agent-based models to include a wider range of validated behaviour types into their modeling. MfE provided funding

### Biodiversity offsets

Biodiversity offsets are increasingly advocated as a means of resolving conflict between development and biodiversity conservation. Generally a loss at the affected site is offset by improving or protecting biodiversity at another site but it is inherently difficult to design fair exchanges because biodiversity is extremely complex. In this sense, biodiversity offsets can be seen as biodiversity loans. But the equity or fairness of these biodiversity loans is difficult to assess because the equity must be assessed in time, space and the type of biodiversity exchanged. We used concepts from financial accounting (to deal with trading over time), combined with biodiversity measures from conservation biology theory to determine fair biodiversity trades in type and space. The approach takes into account both averted biodiversity loss (where the offset increases protection of *similar* biodiversity in other places) and out-of-kind offsets (where the biodiversity gained in the offset is *different* from that affected).

While the calculations and information are complex, we demonstrated a simple and effective way to present the



offset information, even where a fair exchange is difficult to understand. This work is a significant step forward in enabling more robust design of biodiversity offsets.

This research is part of both the Managing Biodiversity and Supporting Trade portfolios, and was supported by Core funding and Cross Department Research Pool funding administered by DOC

### Participatory processes for water management

Land and Water Forum recommendations and government freshwater reform indicate that collaborative processes involving decision-makers and local stakeholders are the future pathway for resolving contentious freshwater management issues and setting water limits. Supporting and refining these processes were an integral part of the freshwater Values, Monitoring and Outcomes (VMO) research programme. VMO was specifically designed to identify solutions to resolve contentious water issues and is providing advice around policy reform in a rapidly changing 'water environment.'

As part of these water reforms, all regional councils will soon be required to run collaborative processes to set limits for water quality and water use; and our 5<sup>th</sup> Regional Council Forum focused on this issue. The forum provided an avenue for three 'early adopter' councils (Waikato, Hawke's Bay, and Canterbury) to compare their respective approaches and for the other three councils to consider where and how they could facilitate collaborative participatory processes within their regions. The VMO experience will provide advice to MfE on new water governance processes.

This research is part of the Enhancing Policy Development portfolio, and was supported by MBIE contestable funding.  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Water trading

Water quality trading could provide New Zealand with greater flexibility and lower the cost of meeting water limits. We reviewed and compared existing and evolving water trading programmes in Australia, New Zealand and North America. We illustrated both differences and similarities between programmes and identified the main hurdles to trading as well as some key factors for programme success. This comprehensive review of what makes water quality trading programmes successful or not will improve the design and implementation of trading programmes.

This research is part of the Enhancing Policy Development portfolio. This analysis was supported by Core funding and MBIE contestable funding; our USA partner was supported by the Packard Foundation.

**Impact 2 (Management):** *Best solutions are identified that integrate economic, social, cultural, and environmental initiatives to maintain or enhance international competitiveness, market access, and social licence for business and industry to operate.*

### Indigenous forestry

The extraction of timber from New Zealand's beech forests has been one of the most controversial environmental issues over the last half century. To provide greater clarity, we reviewed and summarised nearly 20 years of research and experience in implementing beech management systems (allowed for under Forests Act provisions and implemented through MPI's standards and guidelines). The review covered the influence of current harvest systems on tree recruitment, growth and mortality and other natural values such as biodiversity, biological invasions, nutrient cycling, and carbon storage.

Because of our experience in indigenous forestry, we and Lincoln University were invited to host the 8th IUFRO International Conference on Uneven Aged Silviculture, the first time the conference has been held in the Southern Hemisphere. Economical returns from uneven-aged silviculture (exotic and indigenous) can equate to or exceed those of even-aged silviculture, while safeguarding the multiple non-timber services associated with forests (e.g. biodiversity, clean water, recreation and tourism, hunting).

As in many countries, indigenous forests are 'cultural landscapes'. We continue to work with Tūhoe on their Sustainable Forest Management Plan that includes strategies for extracting high value native tawa trees to both create unshaded space for and fund the restoration of native podocarp species with higher cultural value.

Owners and managers of indigenous forests, many of whom represent Māori organisations, are using our research to identify risks to their sustainability credentials and evolve their management systems to mitigate such risks. This should expand access to high-value markets for forest owners and favour indigenous timber production.

This research is part of the Realising Land's Potential portfolio, and was supported by Core funding, MBIE contestable funding and MPI. The restoration forestry work in the Urewera has had considerable in-kind support from the Tūhoe Tuawhenua Trust.  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Sustainability of pastoral agriculture

We contributed to a review of international sustainability assessment schemes for pastoral agriculture, with a focus on measurement tools for value chains and individual beef and sheep farms. We developed and recommended specific indicators for environmental footprint capability (focused on biodiversity) for the FarmIQ database, which will enable the beef and sheep sector to better understand their sustainability performance, manage and report this publicly, and hence sustain their 'licence to operate' from the community. The work has been carried out in collaboration with the New Zealand Life Cycle Management Centre.

This research is part of the Supporting Trade portfolio, and was supported by Core funding and Silver Fern Farms.

### Helping ZESPRI®'s international competitiveness

Landcare Research has assessed the methods used in French eco-labels for kiwifruit and how Zespri's own work could be used to answer queries by French retailers and consumers. The research involved using the latest techniques – a consensus on different footprinting methods determined by international life cycle experts – to compare the compatibility of the footprint methods used in the two countries. Whenever possible, the research updated the previous Zespri studies with new data. Results show methods used to complete the carbon footprints by Zespri and French eco-labelling trial are compatible but the water footprint methods are not because the French methods are too different. Zespri will use the work to understand its relative position across reported metrics and to inform decision making on strategies to further enhance the environmental credentials of its products.

This research is part of the Supporting Trade portfolio, and was supported by Core funding and ZESPRI® International.

### Botrytis in grapes

Botrytis bunch rot is the most important disease of grapes in New Zealand. To minimise fungicide use, current models for managing disease risk are based on knowledge of how disease development is affected by season, climate and vineyard management. However, our recent research is the first to investigate the genetic diversity of *Botrytis* within New Zealand's vineyards. Understanding this diversity is important because *Botrytis* species are known to differ in both pathogenicity and fungicide resistance.

We showed that two species are present in New Zealand vineyards, the highly pathogenic *B. cinerea* and the less pathogenic *B. pseudocinerea*, which is naturally resistant

to the important fenhexamid fungicides. All isolates that showed fungicide resistance were *B. pseudocinerea*, which shows that the New Zealand wine industry is managing the use of this fungicide effectively and avoiding the resistance problems that could make the fungicide unusable.

The work also showed there are regionally distinct, subspecific populations within *B. cinerea* that differ in pathogenicity. Although the practical impact of this is yet to be explored, existing disease risk management models used by the wine industry may need to be modified to allow for these regional differences.

This research is part of the Supporting Trade and Defining Land Biota portfolios, and was supported by MBIE contestable funding subcontract from Plant & Food Research. The PDD fungi collection is Core-funded.

### Fighting Psa disease in kiwifruit

The emergence of pandemic bacterial diseases such as *Pseudomonas syringae* pv. *actinidiae* (Psa) poses significant risk to all the main areas of kiwifruit production in the world. At the time of the Psa outbreak in New Zealand, we worked with ZESPRI/ Kiwifruit Vine Health (KVH) and MPI, using our International Collection of Microorganisms from Plants (ICMP) to identify the Psa disease affecting Bay of Plenty kiwifruit. Since then, we have analysed samples from 61 orchards (over 2400 leaves surveyed) – first by culturing the causal bacterium, followed by DNA sequencing, to determine the within-species 'pathovar', and within that the virulent strain of concern. We are now working on methods to control Psa. Bacteriocins are narrow-spectrum antimicrobials, produced by bacteria to kill closely related competing bacterial species or subspecies. The narrow-spectrum nature of bacteriocins make them particularly attractive as a disease control agent as they are less likely to create broader antibiotic resistance in the wider microbial community, as well as posing a low residue risk for food products. The ICMP collection has been screened for species capable of producing bacteriocins as potential controls. Industry partners (ZESPRI and Comvita) have already expressed interest in the approach.

This research is part of both the Supporting Trade and Defining Land Biota portfolios. Psa investigations were supported by Core funding, MPI and commercial services to KVH. The ICMP (International Collection of Micro-organisms from Plants) is supported by Core funding. Bacteriocins investigations are supported by MBIE's Pre-Seed Accelerator Fund and Landcare Research commercial investment.

### Systematics tools for biosecurity

We also used the ICMP and DNA sequences to provide MPI with a barcoding tool for rapid, accurate identification of *Colletotrichum* – one of the top 10 most important

disease-causing pathogens in the world. The very high quality of this database means that it is suitable for use by biosecurity officers. Without the barcodes, it is notoriously difficult to identify the species associated with each disease. The *Colletotrichum* DNA barcode database is an ongoing collaboration between Landcare Research, CBS (The Netherlands), CABI (United Kingdom) and the International Subcommittee on *Colletotrichum* Taxonomy.

We provided Danish collaborators with specimens and DNA sequences, enabling them to confirm the identity of the new apple disease 'Topaz spot'. Plant pathologists worldwide and biosecurity regulation agencies in New Zealand can now better understand the fungal diseases of modern apple cultivars, and their distribution.

This research is part of both the Supporting Trade and Defining Land Biota portfolios. The ICMP (International Collection of Micro-organisms from Plants) is Core funded. Development of the database was supported by Core funding and AGMARDT.  
www.landcareresearch.co.nz/publications/innovation-stories

### Halving the cost of large-scale control

Aerial baiting is often the only affordable way of alleviating the problems caused by possums and rats in large areas of native forest. For slow-breeding possums, 90–99% reductions in possum density are often achieved, resulting in low numbers for up to 10 years. However, as rat numbers can bounce back within 1–2 years, more frequent control is sometimes desirable but would increase costs. First, we confirmed that sowing baits in narrow strips is as effective for pest control as wide swaths. Then using fixed-wing aircraft (which cost less than helicopters), we showed that, provided the baited strips were no more than about 100 m apart, possums and rats could be controlled effectively but at significantly reduced cost. DOC, Aorangi Trust and AHB (TBfree New Zealand) are now designing a 10-year programme of low-cost aerial baiting every 2–3 years (instead of every 5 years) to determine whether TB could be eliminated from possums at the same time as markedly improving rat control, and, consequently, biodiversity outcomes at little extra cost.

This research is part of both the Supporting Trade and Managing Invasive Weeds, Pests and Diseases portfolios, and was supported by MBIE contestable funding and AHB (now TBfree New Zealand).

### Improving rabbit control

We have significantly refined current practices for rabbit control using aerial application of 1080. Field trials completed in Otago (winter 2011 and 2012) showed reduced per-hectare amounts of bait sown in strips can achieve effective rabbit control, with cost savings of about

40% over current 'total cover' baiting practices. Further trials with bait sown in strips were undertaken in winter 2013.

Carrot bait quality, i.e. uniformity of bait size and toxin concentration, has been identified as a critical factor in the success of rabbit baiting operations. However, producing carrot bait of a uniform size is difficult. We have worked with Otago Regional Council to improve bait quality but current manufacturing practices cannot entirely prevent small carrot fragments (chaff) being produced. Chaff may be sub-lethal to rabbits. Consequently, our strip-sown design aims to maintain high bait density in the strip to maximise the likelihood that rabbits find and consume plenty of baits, to avoid sub-lethal effects. Although there is potential to further improve uniformity in bait size, we suspect that improvements to date will already have reduced potential risks of primary poisoning non-target species.

This research is part of both the Supporting Trade and Managing Invasive Weeds, Pests and Diseases portfolios, and was supported by MPI and in-kind support from Otago Regional Council.

### Cost–benefit analysis of weed biocontrol

We completed a biocontrol cost–benefit study, the first in New Zealand, of the highly successful programme against the weed St John's wort. A model of the potential spread of St John's wort suggested that without biocontrol, 660 000 ha of South Island hill-country pasture would become badly infested. The annual cost of lost grazing to farmers was calculated to be \$109 per hectare, with a smaller annual cost of \$6 per hectare for manual weed control. The Net Present Value (NPV) of the introduction of beetles as a biocontrol agent was between \$140 million (given a conservatively slow rate of spread) and \$1490 million (with a faster rate of spread) over 70 years. The benefit-to-cost ratios were an impressive 10:1 and 100:1 respectively. The savings provided by the St John's wort biocontrol programme, even at the lower end, more than pay for all the other weed biocontrol programmes undertaken in New Zealand to date.

This research is part of both the Supporting Trade and Managing Invasive Weeds, Pests and Diseases portfolios. The analysis was supported by Core funding and used research supported by MBIE and its predecessors.



# VISION MĀTAURANGA



## GOAL

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

Vision Mātauranga is a Government initiative aimed at unlocking the innovation potential of Māori through knowledge, resources and people. Landcare Research's Core Purpose is strongly aligned to this – our research is strongly aligned with the way in which Māori link economic, community and cultural well-being with that of the natural environment.

Landcare Research has a 20-year history of successfully partnering with iwi on a variety of research programmes. Initially our focus was on specific projects with Māori organisations and included developing geographic information systems (GIS) to document cultural values and interests, and protecting and restoring particular taonga species such as kiwi in Te Urewera National Park.

Increasingly we are working in a more strategic way with Māori organisations across a breadth of issues. Māori organisations at different stages in their Treaty of Waitangi settlement processes have quite different science needs. These science partnerships focus on meeting the needs of the particular iwi, with projects ranging from biodiversity and

water quality monitoring, capacity building, and restoration forestry through to enabling Māori to develop capability to manage and govern their natural assets. All projects have integration of mātauranga Māori and science at their heart.

We are committed to building the bicultural capability of our staff, and developing a strong bicultural ethos to ensure staff understand and appreciate the cultural context, dynamics, and environment when engaging and working with Māori communities.

### Key Performance Indicator

- During the year, we engaged in 23 partnerships (23 also in 2012) in which we are linking science and mātauranga Māori in projects with iwi and Māori organisations and projects that address Māori goals and aspirations. Most of these are mature relationships built over several years through multiple projects and interactions.

## Innovations

### Kaitiakitanga of urban settlements

The 3-year research programme Kaitiakitanga of Urban Settlements – Kaitiakitanga o ngā Ngahere Pohatu tackled local government issues such as low Māori participation in urban planning, poor understanding of Māori values, and Māori aspirations and their application in urban planning contexts. A significant outcome of the project has been Auckland Council's implementation of our planning framework. Guided by this framework, the Council and iwi/hāpu planners worked together to integrate mātauranga Māori into the Auckland Unitary Plan for the city's resource management.

This project also built critical expertise within Ngāi Tahu helping them to have significant involvement in urban planning, notably the Christchurch Central Recovery Plan (100 Day Blueprint).

This research is part of the Enhancing Policy Development portfolio, and was supported by MBIE contestable funding.  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Te Kōkiri mō te Whāinga Hua o Ngā Whenua Māori

Landcare Research is involved in Te Kōkiri mō te Whāinga Hua o Ngā Whenua Māori, a new initiative to raise productivity of Māori land. Our involvement stems from our many years of work with iwi, hapū and Māori land trusts and incorporations. The initiative is the private sector's response to the Māori Economic Development strategy 'He Kai kei aku ringa', produced by the Māori Economic Development taskforce. Our role is to highlight the value of science and technology to sustainable land use, including the Māori Land Visualisation Tool to identify potential new opportunities and a decision support system for enabling Māori landowners to make better-informed decisions regarding land use. This aligns strongly with the Vision Mātauranga policy, which seeks to unlock the science and innovation potential of Māori knowledge, resources and people for the benefit of New Zealand.

### Māori Land Visualisation Tool

Landcare Research has upgraded the Māori Land Visualisation Tool (MLVT), an online tool designed to enable Māori landowners to better optimise their land use and identify potential new economic opportunities based on land capability. This year, progress to enhance the MLVT included a new layout, new user-friendly data overlays

(e.g. climate and land cover) and a new enquiry form to better ascertain user needs. The upgraded version uses technology that is consistent with Landcare Research's standard data platform, ensuring better performance and long-term stability of the tool. The new version has drawn favourable reviews by a number of organisations including Te Puni Kōkiri and Te Tumu Paeroa. The new tool will be launched in the 2013/14 financial year.

This research is part of the Characterising Land Resources portfolio, and was supported by Te Puni Kōkiri with some internal investment. Some of the databases accessed are Core funded.

### Vegetation and water monitoring

We provided training for the Waikato Raupatu River Trust on vegetation monitoring at Te Takapū o Waikato ('Maurea Island'), an island on the Waikato River that has recently been returned to Waikato Tainui. The training hui covered the importance of wetlands, how our research supports Waikato Tainui projects and priorities, and discussed the importance of building iwi capability as a key component of our wetlands programme.

Another of our senior scientists is working with Rangitāne iwi and Horizons Regional Council to integrate cultural monitoring of the Manawatu River into formal 'state of environment' reporting for the region in future. The iwi are seeking to extend their ecological monitoring expertise to meet their increased decisionmaking role under the National Policy Statement for Fresh Water Management and the Manawatu River Accord between stakeholders. Rangitāne completed the first iwi summary in the latest Horizons 2013 State of the Environment Report.

These projects are part of the Managing Biodiversity and Enhancing Policy Development portfolios, and were supported by MBIE contestable funding.

Weavers harvesting flax from the National Flax Collection at Lincoln Katarina Tawiri





# SCIENCE COLLABORATION & EXCELLENCE



## GOALS

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

A reputation for science excellence allows us to partner with the world's best research organisations. Excellence is illustrated by our publications and citations (benchmarked internationally), and the professional recognition attributed to our scientists through awards and invitations to participate in national and international research and advisory groups.

In recent years, New Zealand science has progressed from a highly competitive to a more collaborative culture. This trend has facilitated the 'best team' approach through national research centres, networks and hubs that pool capability in particular science areas. The National Science

Challenges will bring a further step change in collaboration, and we have been mindful of this in reviewing our current and future core capability and future skill sets.

We have a well-established track record of collaborating with other research organisations as this enables us to assemble the best scientific capability for tackling environmental issues relevant to our Core Purpose and National Outcomes. Partnerships, centres of excellence and international connectedness enable us to be at the forefront of science and technology developments. This engenders confidence and trust among end-user partners and the wider community in research findings.



# Innovations

## Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services

New Zealand is a signatory to both the Convention on Biological Diversity (CBD) and the newly established Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES). Landcare Research senior staff are actively involved in the IPBES process. One of our scientists, Dr Phil Lyver, was among just 25 experts from around the world to be elected to the Multi-disciplinary Expert Panel (MEP) by the 109 plenary countries represented on IPBES. MEP meetings in Cambridge (UK) and Norway focused on developing the Work Programme for IPBES and reviewing the many proposals submitted by the countries and stakeholder organisations. Dr Lyver was also a member of the Organising Committee for the Indigenous and Local Knowledge Workshop held in Tokyo in June 2013 to develop procedures and approaches for engaging indigenous and local communities in IPBES.

This is part of the Managing Biodiversity Change portfolio, and is supported by MBIE funding.

## Invasive Animals CRC

Landcare Research is a Core Participant in the Invasive Animals Cooperative Research Centre (CRC), an extensive AU\$19.7 million programme of research and extension activities. We target pest management problems of concern to both New Zealand and Australia.

We began work on four projects that will enhance our mutual capability in biological control of rabbits (potential new virulent strains of rabbit haemorrhagic disease (RHD) and overcoming immunity derived from benign calicivirus infection); widely- applicable ecological modelling frameworks that better include stakeholder needs; improved decision support systems (which include biodiversity outcomes and stakeholder needs) to prioritise pest management at local and national scales in New Zealand and Australia; and improved understanding, surveillance (including citizen science methods for monitoring) and forecasting of mouse plagues in Australia.

The projects are part of the Managing Invasive Weeds, Pests & Diseases portfolio. Participation in the CRC was supported by Landcare Research strategic investment; the research projects are co-funded by the CRC and hence provide significant return on our investment.

## Global change and trade

Through this strategic investment project we are collaborating with the Computation Institute and University of Chicago to have exclusive access to global-scale simulation studies on climate impacts on crop yields for our global integrated assessment modelling work for MPI. This year, we are close to finalising forest productivity simulations, including how alternative management strategies perform under a changing climate and quantifying important uncertainties around these results – a significant step forward from previous simulation studies carried out in New Zealand. We are now focusing on developing a spatially detailed and dynamic economic model of land-based production in New Zealand and next year this will be linked to the global integrated assessment model to estimate impacts of global climate change on the production and export's value of New Zealand's primary sectors (i.e. agriculture and forestry).

This project is part of the Enhancing Policy Development portfolio, and is supported by Landcare Research strategic investment.

## OzFlux and KiwiFlux workshop

Landcare Research hosted the annual OzFlux and KiwiFlux workshop on measuring exchange of greenhouse gases between the ecosystem and the atmosphere. The workshop (attended by over 50 researchers, mainly from overseas) emphasised the importance of emissions from agricultural sources, including measurement and mitigation of agricultural greenhouse gas from dairy activities. A key focus of the workshop was the importance and challenges in making accurate measurements and improved data interpretation. Information disseminated from this workshop will be used by universities and research organisations in Australia and New Zealand to reduce the uncertainty in greenhouse gas emissions inventories.

The research is part of the Measuring Greenhouse Gases and Carbon Storage portfolio, and was supported by Core funding.

## Global Plants Initiative

The Global Plants Initiative (GPI) is an international partnership of more than 270 herbaria representing over 70 countries with the goal to digitise type specimens of plants, fungi and algae (the specimens from which a species was first described) and other holdings and make these available for scholarly purposes through JSTOR Plant Science. To date, over 1.6 million type specimens from around the world are available for viewing. For the last 10 years the US-based Andrew W. Mellon Foundation has led and funded the project.

Our Allan Herbarium became a GPI partner (as a member of the Council of Heads of Australasian Herbaria (CHAH)) in late 2012. The Royal Botanic Gardens at Kew sent the Herbarium a HerbScanner and the HerbScan frame; and the Netherlands sent a Leaf Aptus Camera. In addition to this equipment that the Allan Herbarium is allowed to keep, the Mellon Foundation is also funding a technician to digitise about 2000 Allan Herbarium sheets containing type specimens of vascular plants. This work also benefits users of the New Zealand Virtual Herbarium, including those from biodiversity and biosecurity sectors, as well as contributing to global sharing of high resolution digital images of type specimens.

This digitisation project is part of the Defining Land Biota portfolio, and is supported by the Mellon Foundation. The Allan Herbarium is supported by Core funding.

### Antarctic Environments Portal

This year, we signed an agreement with Antarctica New Zealand to jointly develop an Antarctic Environments Portal that will provide an easily-accessible, unbiased scientific evidence base to support Antarctic policy agencies such as the Committee for Environmental Protection (CEP). With the increasing environmental pressures on the continent, agencies such as the CEP need to be able to access this evidence-based information quickly and efficiently to support the goals of the Antarctic Treaty.

The portal will also draw on our extensive informatics capability to provide a mapping interface with which to explore the continent and show new geospatial information. The portal will also contain short reports that summarise the state of knowledge on the priority issues and science-focused discussions on emerging issues within Antarctica. Users will be able to search, explore and browse the information, which, in turn, will continue to evolve as policy priorities change and as the science knowledge base to support the information grows.

At the recent Antarctic Treaty meetings in Belgium, the progress of the portal was highlighted in a presentation and video that we prepared for Antarctica New Zealand, to show the current state of the portal and visually showcase the work and concept to the Antarctic Treaty member countries. The response to the project was very positive, by both acknowledging the significant progress that has been made but also strongly supporting the ongoing project.

This research is part of the Characterising Land Resources portfolio, and is supported by Core funding and Antarctica New Zealand.

### Supporting government initiatives overseas

We support New Zealand's multilateral/bilateral environmental commitments, trade agreements and Official Development Assistance in Pacific Island Countries through capacity-building projects. This year, for example, we worked with AsureQuality and the Ministry of Foreign Affairs and Trade (MFAT) to develop a programme for technical cooperation to help develop biosecurity and systematics capability in the Indonesian Quarantine Agency (part of the Ministry of Agriculture).

In areas of our core capability, Landcare Research partners with New Zealand government agencies (MFAT, MBIE); international funders (private sector, philanthropists, NGOs, national governments and donors); and overseas universities and science agencies on science projects across many countries in South America, India, SE Asia, the Pacific, China and South Korea. Much of this work centres on invasive species management, biodiversity, improved land management, and methodologies for greenhouse gas – carbon storage inventory.

Our partnerships with national science agencies in Chile and China are aligned with New Zealand Government initiatives in those countries.

These projects are provided by several portfolios.

### Cost-benefit analyses tools to manage invasive species

Following successful workshops on assessing the management of invasive species using rigorous cost-benefit analyses in the Pacific, two of our staff collaborated with the Pacific Invasives Initiative and CABI to develop and lead a similar workshop in Trinidad and Tobago. Participants represented the Bahamas, Dominican Republic, Jamaica, Trinidad and Tobago, Saint Lucia and Mexico. All these countries (save Mexico) are involved in the GEF-funded project entitled 'Mitigating the Threats of Invasive Alien Species in the Insular Caribbean'. The course took participants through an overview of invasive species management, the steps involved in conducting cost-benefit analysis, the cost-benefit tool developed by Landcare Research, and techniques for non-market valuation. The course was well received and had a high level of participation. Participants will work on their own cost-benefit analyses case studies, which will be completed by the end of this year and be the basis for a publication.

This research is part of the Enhancing Policy Development portfolio. The project was funded by the Critical Ecosystems Partnership Fund (which receives funding from seven organisations) and GEF (Global Environment Facility).

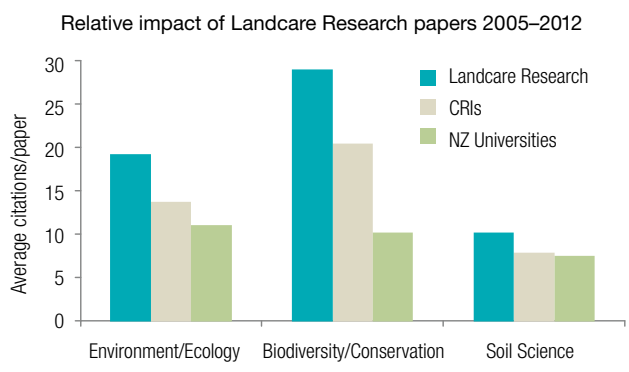
# Benchmarking Our Science Quality

We now use the Thompson Reuters' Incites™ database to benchmark the quality of our science publications (output and impact) in our key research areas. Bibliometric analyses provide independent verification that our science is highly regarded. Incites™ also enables more detailed analysis than the previously used SciMAGO reports, and also allows us to track trends in our publication metrics more easily. Data below is from the 'Global Comparisons' section of the Incites database.

From 1992–2012, Incites™ has indexed 3346 publications with Landcare Research staff as lead- or co-authors, which have been cited over 64 570 times; an average citation rate of 19.3 for the 20-year period.

From 2005 – 2012 Incites™ indexed a total of 1559 publications with Landcare Research staff as lead- or co-authors. These publications have been cited over 18 000 times, 13% more than for the global "average" paper.

From 2005 to 2012 Landcare Research produced 14% of all science journal publications from CRIs and New Zealand universities in the environment/ecology subject area. We also published 24% and 15% respectively of New Zealand's soil science and biodiversity conservation publications. The impact of Landcare Research's publications, measured by average citations per document was higher than for any other CRI or New Zealand university in all three research areas (see below). Our biodiversity /conservation publications received over twice as many citations as the global 'average' paper in this research area.



Professor Sir David Skegg, President of the Royal Society of New Zealand, awarding David Whitehead being a Fellow of the Royal Society of New Zealand RSNZ  
 Peter Heenan receiving the New Zealand Journal of Botany prize from senior editor Kevin Gould NZJB





## Key Performance Indicators

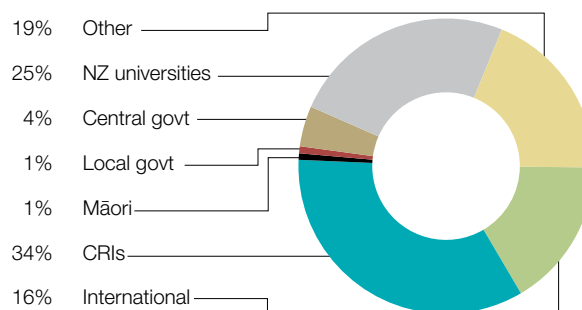
- MBIE's external Stakeholder Survey showed 85% of respondents for Landcare Research have confidence that we have the ability to put together the most appropriate research teams (91% in 2012)

For the year ended 30 June:	2010	2011	2012	2013
Data include our Research Associates but exclude staff in any collaborating or subcontracted organisation				
<b>Collaboration</b>				
Memoranda of Understanding (MoU)	16	10	6	11 <sup>1</sup>
<b>Science excellence</b>				
Professional recognition and awards for staff	24	21	15	15 <sup>2</sup>
Keynote or plenary addresses (costs fully or partly covered)	9	11	8	11
Number of editorial positions	106	96	82	85 <sup>3</sup>
Number of positions in professional societies	55	59	56	54 <sup>4</sup>
Number of roles on advisory panels and groups	127	133	143	142 <sup>5</sup>
Number of directorships	24	17	17	14 <sup>6</sup>
Number of peer-reviewed scientific papers	271	243	241	274 <sup>7</sup>
% of papers in top 25 journals relevant to the scope of our research	NA	NA	30%	31.6% <sup>7</sup>
Average number of citations over a rolling 8-year period	NA	NA	10.8	11.2

- 1 MoUs include 3 signed with New Zealand organisations and 8 overseas
- 2 15 awards (excluding travel grants) made to 14 staff (page 41). In addition Landcare Research was recognised in the Sustainable 60 Awards
- 3 40 staff hold 85 positions on the editorial boards of scientific journals; 71 of these are international and include the mega journal Zootaxa, founded by one of our staff
- 4 36 staff hold 54 positions in professional societies (including 10 Fellows); 19 of these positions are international
- 5 60 staff hold 142 positions on advisory boards, technical groups and review panels; 41 of these are international
- 6 11 staff hold 14 directorships or board memberships; 4 of these are international
- 7 Web of Science metrics at July 2013. Numbers may be lower than actual due to delays inherent in the process of indexing and abstracting by Web of Science.

### Subcontracts to research partners by sector

Total = \$6.96m in 2012/13 (\$7.12 in 2011/12)



Other includes business sector, NGOs and private individuals. Subcontracts to Māori research partners in 2013 are less than in 2012 (3.8%) due to two jobs that ceased in the 2013 year.

### Joint peer-reviewed publications (*Web of Science*\*)

For year ended 30 June	2011/12	2012/13
With other New Zealand organisations	39 (27%)	76 (39%)
With overseas organisations	105 (73%)	118 (61%)
<b>Total</b>	<b>144<sup>1</sup></b>	<b>194<sup>2</sup></b>

- 1 Does not include 30 publications with only Landcare Research authors
  - 2 Does not include 37 publications with only Landcare Research authors
- \* Web of Science has fewer publications for Landcare Research than what is recorded by our own library. While there may be up to a 6-month delay in Web of Science indexing New Zealand journals, the trend to early online publication has considerably reduced this time lag. We take publication to be when the paper first becomes available.

## Honours, prizes

1. Peter Heenan was awarded the *New Zealand Journal of Botany* inaugural prize for Sustained Excellence in Contributions to Southern Hemisphere Botany.
2. Malcolm McLeod was awarded the honour of presenting the Norman Taylor Memorial Lecture by the President of the NZ Society of Soil Science in recognition of outstanding contributions to soil science in New Zealand.
3. David Whitehead, our Chief Scientist, was elected a Fellow of the Royal Society of New Zealand in recognition of his major contributions to research into plant–soil processes and greenhouse gases from terrestrial systems, and the mentoring of younger scientists.

## Prestigious grants

1. Bill Lee was awarded a Marsden Fund Grant of \$920,000 over three years to investigate whether history matters in plant community assembly and rates of speciation. He will collaborate with colleagues at Landcare Research, York University (Canada) and Stanford University (USA).
2. Ana Ramon-Laca was awarded a QEII Technicians' Study Award.
3. Surinder Sagar was awarded a Japan Society for the Promotion of Science Invitation Fellowship.
4. Norman Mason was awarded a grant from the Royal Society of New Zealand's Dumont d'Urville NZ–France Science & Technology Support Programme.

## Professional positions

1. Murray Dawson was appointed as Registrar for the Royal New Zealand Institute of Horticulture (RNZIH), only the second person since 1958 to hold the position.
2. Bill Lee was also appointed as an Honorary Professor at the University of Otago.
3. Phil Lyver was one of just 25 scientists from around the world to be elected to the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). (Refer page 37)
4. Dan Tompkins was elected onto the Council of the Wildlife Disease Association, the international professional body for wildlife disease research, the first Australasian to sit on the Council.

## Competitive awards

1. John Innes was one of three finalists in the Environmental Science category of the Hamilton Science Awards Trust (Kudos) Awards.
2. Landcare Research was a finalist in the Sustainable 60 Awards for all four of the categories we entered – Strategy & Governance, Workplace, Marketplace and Overall Large Company. We were runner up in the Strategy & Governance and Overall Large Company categories.

## Service awards

1. Trevor Crosby was presented with a special award by the Entomological Society of New Zealand in recognition of his outstanding contribution as editor of the *Fauna of New Zealand* monograph series, which celebrated 30 years of continuous publication, with 70 volumes.
2. Aaron Hicks was recognised by the Tuakiri Access Federation for his technical consultancy services to the Federation, and was part of the Tuakiri team that won the Overall Award at the 2012 Microsoft Tertiary ICT Innovation Award.
3. Dave Morgan received a Shield in recognition of his exemplary 6 years' service on the National Animal Ethics Advisory Committee.

## Collaboration with Universities

All our larger sites are on or close to university campuses and we have a number of joint appointments with New Zealand universities. This facilitates collaborative research, and makes it easier for our staff to supervise postgraduate students and present invited lectures. We are also developing more strategic opportunities for summer students within our research programmes.

To encourage many more PhD students into our research programmes, we have increased the number of part-time appointments (seven) of our high performing scientists to our Joint Graduate School with the University of Auckland.

During the year, we hosted 16 postdoctoral researchers – talented young researchers embarking on science careers, more than half of whom are from New Zealand with the others coming from Australia, Canada, the Netherlands, Pakistan, Spain and the UK.

### Links with universities

<i>For year ended 30 June:</i>	2010	2011	2012	2013
NZ university staff in our research projects	48	38	41	42 <sup>1</sup>
Our staff in university projects	18	13	13	7 <sup>2</sup>
Postgraduates being supervised by our staff	98	71	102	48 <sup>3</sup>
Staff paid to lecture in university courses	14	12	7	10 <sup>4</sup>
University positions held by staff	41	36	39	29 <sup>5</sup>

1 42 staff and postgrad students from 8 universities collaborating in 33 of our research projects

2 7 of our staff in 7 programmes at 3 universities

3 38 PhD, 9 MSc and 1 postgraduate diploma (does not include students supervised by overseas research associates). The significant drop reflects the completion of a large number of theses

4 10 staff delivered 15 sets of paid lectures; another 22 staff provided 25 sets of guest lectures for no fee

5 22 staff hold 29 honorary positions (professorships, lectureships, fellowships) in New Zealand and overseas universities

## Collaborative research centres, networks and consortia

We are partners with universities, CRIs and other agencies in a number of national and international research centres, consortia and networks in areas relevant to our National Outcomes and capability as outlined in the Scope of our Core Purpose.

### Outcome 1: Biodiversity

- Centre for Biodiversity and Biosecurity (CBB) [www.cbb.org.nz](http://www.cbb.org.nz)
- Regional Councils' Biodiversity Forum
- Invasive Animals Cooperative Research Centre [www.invasiveanimals.com](http://www.invasiveanimals.com)
- Southern Temperate Ecosystems Research Network (STERN)
- Global Biodiversity Information Facility (GBIF) [www.gbif.org](http://www.gbif.org)
- Species2000 Catalogue of Life [www.sp2000.org](http://www.sp2000.org)

### Outcome 2: Land resources

- Sustainable Land Use Research Initiative (SLURI) [www.sluri.org.nz](http://www.sluri.org.nz)
- Sustainable Land Use Alliance (SLUA) and National Land Resource Centre (NLRC) [www.nlrc.org.nz](http://www.nlrc.org.nz)
- Global Soil Map [www.globalsoilmap.net](http://www.globalsoilmap.net)
- New Zealand Antarctic Research Institute <http://nzari.aq>

### Outcome 3: Greenhouse gases

- New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) [www.nzagrc.org.nz](http://www.nzagrc.org.nz)
- New Zealand Climate Change Centre (NZCCC) [www.nzclimatechangecentre.org](http://www.nzclimatechangecentre.org)
- Global Research Alliance [www.globalresearchalliance.org](http://www.globalresearchalliance.org)

### Outcome 4: Industries and business

- New Zealand Life Cycle Management Centre <http://lcm.org.nz>
- New Zealand Centre for Sustainable Cities <http://sustainablecities.org.nz>
- Sustainable Business Council [www.sbc.org.nz](http://www.sbc.org.nz)
- Better Border Biosecurity (B3) [www.b3nz.org](http://www.b3nz.org)



# INFORMATICS & SYSTEMATICS



## GOAL

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

Informatics is the design and development of information systems that can gather and manage data (often from distributed sources) and deliver information as and when needed, often through web portals. The key underlying principles for web portals are that publicly-funded data are open (discoverable) and conform to international data standards, in forms that are usable by humans and computers. A key focus is interoperability standards – ensuring our computer systems work seamlessly alongside those of our national and international stakeholders. These developments are being enabled by high network speeds, such as the ultra-fast broadband roll-out, KAREN (Kiwi Advanced Research and Education Network) and the High Performance Computing facilities being operated under the National e-Science Infrastructure (NeSI) investment.

We have a vested interest in knowledge stewardship – maximising new uses for existing data, acquiring new data when and where they are needed, software and data-sharing synergies, data integrity, and data uptake and use by others. We develop new software applications to enhance knowledge transfer and increase national and

international access to, and interoperability of data from, our research programmes and our Nationally Significant Databases and Collections.

Policy funding agencies increasingly depend on e-science and robust integrative modelling across local, national and even global scales. The private sector also needs to be able to derive value from Core-funded datasets.

### Key Performance Indicator

- The response to last year's online survey of people using our Nationally Significant Databases and Collections was very positive (as reported in the 2012 Annual Report). The survey is now being conducted biennially to avoid 'survey fatigue'. We continue to work closely with key user groups, and respond to user requests. Where major projects are planned (such as LCDB updates), we work closely with a steering group of stakeholder representatives.

## Key Initiatives

### National e-Science Initiative (NeSI)

We are partners in the \$48 million National e-Science Infrastructure (NeSI) investment by Government, three universities and one other CRI to build and operate three High Performance Computing facilities. NeSI enables us to carry out advanced modelling for applications across all Landcare Research's Outcome areas. Examples of projects made possible through the NeSI investment include:

- Processing single species and population genomics for stick insects and giant weta in a fraction of the time previously needed – knowledge of conservation genetics is of significant benefit to understanding and managing our biodiversity
- Simultaneously analysing clusters of 7000-19 000 vegetation plots recorded in NVS for a quantitative classification of New Zealand's plant communities
- Processing of remote sensing data (e.g. cloud masking, satellite image mosaicking, image feature segmentation) for the Land Cover Database (LCDB) project
- Pest population modelling at the national scale (ultimately multi-species population modelling will be required for Predator-Free NZ)
- Storing and manipulating large-scale LiDAR datasets and spatial imagery to support regional council decision-making on flood management and potentially a range of other environmental and land use decisions

NeSI supports work in multiple portfolios, and is supported by Landcare Research strategic investment.

### Data management and data warehousing

Data management is a common challenge for scientific organisations the world over. Our effectiveness in delivering environmental solutions depends upon our ability to access, process and store data and make information available in user-friendly fit-for-purpose ways to meet emerging policy and practices, and realise new opportunities across all our National Outcomes.

As part of a pan-CRI group, we reviewed and analysed best-practice research data management plans and the sharing of public research data across 13 organisations in New Zealand and overseas. From this we identified the core elements for effective policies, processes and systems to meet both internal and external requirements, including meeting evolving global standards in data management and contractual data obligations.

We have established a new half-time role of Research Data Manager. One of their first tasks has been to choose a research data repository system (data archive) primarily to manage the myriad of smaller datasets that support our day-to-day research.

This project is supported by Landcare Research strategic investment.

## Databases & Collections Usage

### Land and soils databases

These are part of the Characterising Land portfolio, and are supported by Core funding. [www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

Land Resource Information Systems (LRIS)– provides access to the Land Resource Inventory (NZLRI), the national Soils Database (NSD), S-map, digital elevation models (DEMs) <a href="http://lris.scinfo.org.nz">http://lris.scinfo.org.nz</a>			
	2012	2013	% change
Visits	12,816	17,258	+35%
Page views	128,956	180,245	+40%
Total registered users	1143	1956	+71%
Data downloads	2976	3941	+32%

Strong increase in usage for both the Land Resource Information Systems (LRIS) Portal and S-map Online reflect a good match to target audience requirements. LRIS is now being used for data archiving internally by staff and externally by stakeholders (ECan and National Rural Fire Authority), which demonstrates LRIS' value well beyond its initial purpose as a public data download site.

S-map Online– the new national soils database that provides access to digital soil information, including maps and fact sheets (2012 data covers 11 months only) <a href="http://smap.landcareresearch.co.nz/">http://smap.landcareresearch.co.nz/</a>			
	2012	2013	% change
Visits	11,061	18,845	+70%
Application loads*	9254	16,129	+74%
Soil factsheets	10,385	20,437	+97%
Point queries	13,391	25,931	+94%
Maps printed	724	1541	+113%

\*Each application load equates to clicking the button on the home page to start the mapping software.

Major updates to the functionality of S-map include the way that profile-available-water (PAW) is calculated, and the ability to feed soil data directly into the Farm Dairy Effluent Storage Calculator (an AgResearch product) that depends on soil properties. All S-map factsheets have been updated to include hyperlinks to an extended glossary, which helps users understand the data.

We upgraded the Soils Portal website ensuring users have increased access to soil data assets that are not accessible through S-map Online. Maps and data can be viewed and requested for the New Zealand Soil Classification, the Fundamental Soils Layers, the National Soils database (NSD) sites and Ross Sea Region soil sites. Novel data-visualisation features (e.g. layer transparency, also used in S-map Online) assist map users. The upgrade is an important step in consolidating access to all our soil data assets.

<b>Our Environment</b> – provides access to a wide range of environmental data. (** 2012 data covers 7 months only so no increase/decrease calculated) <a href="http://ourevironment.scinfo.org.nz/">http://ourevironment.scinfo.org.nz/</a>			
	2012	2013	**
Visits	4487	6226	**
Application loads*	2633	2949	**
Point queries	1280	2175	**
Maps printed	NA	844	**

\*Each application load equates to clicking the button on the home page to start the mapping software.

New and updated maps available through Our Environment include the Basic Ecosystems (2008) dataset and National Wetlands (current and historical) dataset.

<b>National Vegetation Survey Databank (NVS)</b> – includes plot records, maps and photos spanning 50 years <a href="http://nvs.landcareresearch.co.nz/">http://nvs.landcareresearch.co.nz/</a>	2012	2013	% change
Datasets provided on request	1195	3362 <sup>2</sup>	+ 181%

<sup>1</sup> There were 11,200 page views.

<sup>2</sup> 38 requests involving 3362 datasets Excludes datasets available online through NVS Express.

In addition, 22 peer-reviewed paper, 8 conference presentations, 3 contract reports and 1 thesis were based on NVS data.

The NVS website was completely redeveloped this year. As well as a fresh new look, several new features have been introduced, such as improved search, new location maps, and the capability to approve data requests and download data online.

Planned strategic investment to digitise paper records (as per the SCI 2012–17) was deferred.

Kerry Ford (author of a Guide to Grasses of New Zealand) in tussock grassland  
Maureen Fletcher handling cultures of micro-organisms from plants  
Ilse Breitwieser  
Simon Baker





## Biological collections and databases

These are part of the Defining Land Biota portfolio, and are supported by Core funding.

Specimens loaned or gifted from Nationally Significant Biological Collections <sup>1</sup>	2012	2013	% change from 2012
NZ Arthropod Collection (NZAC), including nematodes – specimens	4785	6693	+40%
International Collection of Micro-Organisms from Plants (ICMP) – cultures	598	1289	+115%
NZ Fungal Herbarium (PDD) – specimens	263	599	+128%
<i>Associated database (for PDD and ICMP) – page views</i>	140,658	496,366 <sup>2</sup>	+253%
Allan Herbarium (CHR) – specimens	4063	3734	-8%
<i>Associated databases – page views</i>	206,812	196,855	-5%
NZ flax & living plant collections	25	17	-32%
<i>Ngā Tipu Whakaoranga Ethnobotany Database – page views</i>	22,640	36,529	+61%

- 1 Data are for outward specimens and do not include incoming loans, exchanges or additions to collections.
- 2 Includes NZFungi and NZFungi2. This huge upsurge reflects the launch of the new NZFungi2 website in April 2012 to increase access to the PDD and ICMP databases; NZFungi2 has significantly increased functionality compared to the old NZFungi pages.
- 3 Specimen data are available online through our systematics databases (<http://scl.landcareresearch.co.nz/>), the NZ Virtual Herbarium ([www.virtualherbarium.org.nz](http://www.virtualherbarium.org.nz)), the NZ Organisms Register ([www.nzor.org.nz](http://www.nzor.org.nz)), and the Global Biodiversity Information Facility ([www.GBIF.org](http://www.GBIF.org)).

This year, we made some significant additions to the open-access e-Flora web portal ([www.nzflora.info](http://www.nzflora.info)), an important resource covering native and naturalised marine and terrestrial plants in New Zealand. The new information includes three genera that are ranked in DOC's Threatened Plant Classification. New descriptions and distributions of weed species such as *Azolla*, *Equisetum*, *Marsilea* and *Salvinia* will also be of value to conservation and biosecurity managers. A revision of coastal cresses (*Lepidium*) recognised 11 new native species; all have high conservation values and are actively managed by DOC.

We also launched two new online interactive botanical keys for the identification of native orchids (a family with probably the highest conservation values of any in New Zealand) and flowering plant genera (the first such key), and

an update of the grasses of New Zealand (a difficult group for non-specialists to identify). The keys link to *Ngā Tipu o Aotearoa*, Landcare Research's plant names database.

The collections continued to provide identification and information services on request, e.g. the Allan Herbarium provided 1042 identifications and 93 sets of information to DOC, MPI, regional councils, nurseries, researchers and the general public.

Recent developments in invertebrate systematics included progress towards a revision of Noctuidae moths (many native species are threatened or associated with threatened ecosystems; many exotic species are high-risk pests); and new coverage of Carabidae (often used as biological indicators, with about 60% of New Zealand ground beetles being endemic). We also published the first ever identification guide to Ichneumonid parasitoid wasps (one of the largest families of invertebrates in New Zealand). These groups of insects are economically and ecologically important.

## NZOR

Landcare Research is custodian of and curates seven 'Nationally Significant' biological, soil and natural resource databases and collections – the largest holding for any of the CRIs, and larger than equivalent collections held by museums in New Zealand. The New Zealand Organisms Register (NZOR) is an excellent example of how our informatics capability has significantly increased access to taxonomic data associated with our biological collections plus equivalent data managed by NIWA and Te Papa Tongarewa. NZOR creates one dynamic, freely-available virtual national resource. Data can be directly integrated into biodiversity and biosecurity systems used by central government ministries, departments, and agencies, local government, research institutes, NGOs and the wider community. NZOR aligns with Open Government policies and fits within emerging e-Government initiatives.

NZOR is the most complete digital species catalogue of any country, and represents a significant national contribution to global efforts such as the Catalogue of Life, the Global Biodiversity Information Facility (GBIF) and Group on Earth Observations Biodiversity Observation Network (GEO BON), to support evidence-based reporting of the status and trend of biodiversity globally.

NZOR is part of the Defining Land Biota portfolio. Development of NZOR was funded through TFBIS.

# KNOWLEDGE & TECHNOLOGY TRANSFER



## GOALS

1. Landcare Research is at the leading edge of technology and knowledge delivery to users.
2. Landcare Research adds value to the New Zealand economy through commercially viable products and services, their transfer to partners in the private sector, and overseas licensing, where appropriate.

Technology and knowledge transfer are core activities that support development of effective government policy, improve the environmental and economic performance of government agencies, business and industry, and engage the community. Effective transfer requires engagement across many levels of stakeholder organisations and at all stages of a project. Where appropriate, we second our staff to regional councils, AHB/TBfree New Zealand and government agencies specifically to assist with the uptake and implementation of research.

Our Toxicology, EcoGene, Environmental Chemistry and Soils laboratories offer a range of fee-based specialist services to a range of clients (mostly New Zealand-based) in addition to supporting our own research needs.

New technologies with potential commercial application are developed to investor-readiness with the commercialisation expertise of both Auckland UniServices and KiwiNet. This year, we signed a licensing agreement with a New Zealand

company for the worldwide commercialisation of our precision irrigation positioning technology.

Through our subsidiary company carboNZero Holdings and our Enviro-Mark programme, we provide a range of environmental certification services, which are strongly aligned to our Core Purpose and the Development within Environmental Limits Outcome in particular, to clients in New Zealand and overseas. We regularly review commercial business ownership, value and related risk issues. On 1 July 2013, we merged all these certification services into one company.

We continued the range of information-sharing initiatives that include print and e-newsletters tailored to the interests of stakeholder groups, video clips, workshops, hui and seminars. Our Wellington lunchtime briefings to government stakeholders on topical research issues attract good audiences and constructive debate among our stakeholders.

## Innovations

### carboNZero<sup>Cert™</sup> Holdings

This year, our wholly-owned subsidiary carboNZero Holdings significantly improved its financial performance; total certifications increased by 29%. Thanks to ISO 14065 JAS-ANZ accreditation, the company was contracted to undertake its first audit under the Negotiated Greenhouse Gas Agreements.

To date carboNZero Holdings has undertaken over 95% of all the voluntary accredited greenhouse gas certifications across Australia and New Zealand. Three of the UK CEMARS<sup>®</sup> certified clients were in the top 10 companies (out of 2000) for improving energy efficiency and reducing greenhouse gas emissions under a mandatory scheme regulated by the Environment Agency.

Investment in a new software platform will enable the development of additional environmental certification products beyond carbon and a more integrated service offering for clients.

On 1 July 2013, carboNZero Holdings merged its existing services with those of Enviro-Mark<sup>®</sup> to extend the range and value of products and services available to clients. The new company is now called Enviro-Mark Solutions Limited.

### Enviro-Mark<sup>®</sup>

The Enviro-Mark programme continued to maintain its strong position in the New Zealand market with 175 clients (similar to the number of clients for ISO 14001 certifications) making it one of the leading Environmental Management Systems in this country. The focus for the year has been to deliver increased value to existing members. Initiatives included enhancing audit capacity (providing greater flexibility for clients in regard to audit timing and costs), and running events and training sessions to build capability within member organisations. The newly introduced 'Enviro-Mark for Absolute Beginners' workshops and our flagship seminars 'Get the Green Advantage' were consistently well-attended. Retention in the programme has remained high at over 85%. Over 65% of the programme members have at least Gold-level certification, which means they have gone well-beyond Bronze entry-level compliance requirements and have set up objectives and targets to enable continuous environmental improvements within their organisations.

### Specialist laboratory services

We have several specialised laboratories, each with dedicated staff, that provide essential support to much of our research. All of these labs – ecological genetics (EcoGene), toxicology, environmental chemistry, soil contamination, mineralogy and soil physics – also provide fee-based services, developed from our research and analytical expertise, to a range of clients. In collaboration with the University of Canberra we launched EcoGene Wildlife DNA services in Australia and are now providing services from facilities in Canberra and Auckland.

Clients for laboratory services are mostly government agencies, local government, other CRIs and universities but work is also undertaken for developers and consultants. All these commercial services are closely aligned to our Core Purpose so are instrumental in benefitting New Zealand; they also derive additional benefit for Landcare Research from capital investment in laboratories.

### Innovative lysimeter technologies

Following the on-farm success of our channel lysimeter, which is now operated by Otago Regional Council, we developed a prototype pipe lysimeter that has the potential to measure nutrient leaching over a much larger scale than existing devices. The prototype pipe lysimeter has been installed on a prominent Canterbury dairy farm and is operating very well, intercepting all soil water drainage events in the first six months of operation. Results have been presented to regional council, industry, and research agencies resulting in joint funding applications for further development.

We also developed a new suction-cup lysimeter for NIWA. Unlike other standard suction-cup lysimeters in common use, which sample both mobile and immobile soil water, our new design only samples the mobile water responsible for carrying contaminants through the soil profile.

Funded from commercial investment and PSAF. Suction lysimeter: commercial funding from NIWA.

### 'Proof-of-Freedom' from TB

Using a quantitative 'proof-of-freedom' framework largely developed by us, AHB/TBfree New Zealand revoked the Vector Risk Area status for 32 management units totalling 400,000 ha, effectively declaring that TB had been eradicated from vectors in those areas. As the national aim is to declare an average of 166,000 ha TB free each year from 2011–2026, the TB programme is comfortably on track to meet or exceed its eradication targets.



### Predator-Free New Zealand

Technology and knowledge transfer will be vital in progressing the Predator-Free New Zealand concept at community, local and regional scales. In addition to our work with national and local government, we work with numerous NGOs and community-led groups that are part of the Sanctuaries of New Zealand Network. We host the Sanctuaries website ([www.sanctuariesnz.org.nz](http://www.sanctuariesnz.org.nz)) and coordinate an annual workshop for sanctuary stakeholders.

Research to develop cost-effective, environmentally-sensitive and humane pest management strategies and control products specifically targets the needs of community groups as well those of commercial contractors working for DOC, AHB/TBfree New Zealand and local government. Products such as traps, baits and toxins are licensed to commercial partners in the New Zealand market to speed their availability.

For more information about Predator-Free New Zealand:  
[www.landcareresearch.co.nz/publications/innovation-stories](http://www.landcareresearch.co.nz/publications/innovation-stories)

### Biological indicators of water quality

Much of the water quality monitoring at local scale is carried out by community groups who contribute to local projects and regional freshwater goals. Landcare Research is making relevant science available through a newly developed online Freshwater Invertebrates Identification and Information Resource. Invertebrates are a sensitive indicator of water quality and contamination. As water quality in many areas continues to decline, this type of resource can help councils, community monitoring groups and the general public understand how declining water quality affects freshwater ecosystems. These invertebrates are important indicators for monitoring how effective environmental policy and community and industry management efforts are and where remedial action is required.

### Expert evidence in resource management

All parties to court proceedings have the right to access relevant scientific advice and evidence. Landcare Research is a repository of specialist knowledge that may not be available elsewhere, and so our staff and research findings are often used in expert, impartial evidence for resource consent applications or appeals, regional or district council resource consent hearings, and Environment Court appeals. For example, our research has been used in legal decisions that have provided greater protection in district plans for threatened eastern dryland ecosystems of the South Island.

Also this year, we supplied information to all parties considering proposed agricultural development on a significant area of frost flat, a naturally uncommon ecosystem. Development was rejected and the area protected. Taupō District Council, DOC and Wildland Consultants used our research as evidence in working with the owners, Stevenson Holdings, to negotiate a reasonably satisfactory outcome for all concerned.

Similarly, our research on naturally uncommon ecosystems influenced a court decision not to allow dams on the upper Hurunui River because of the importance of Lake Sumner and its margins.



Stephen Moore helping a school group identify freshwater invertebrates. Birgit Rhode

### National Land Resource Centre

To foster greater use and uptake of science, and address the needs identified by stakeholders the NLRC has continued to develop the website ([www.nlrc.org.nz](http://www.nlrc.org.nz)) providing users with the most current and up-to-date science information and news from across and beyond the science community in a friendly and engaging way. It incorporates a unique geo-referenced search capability allowing users to find science, resources and organisations active in their region.

New methods for communicating complex data are exemplified by a video showing the successive waves of urban expansion onto high-class rural land around Auckland between 1990 and 2008, a visual interpretation of a 2012 study that we led.

### Wellington Link seminars

The monthly Landcare Research Link seminars in Wellington continue to attract an ever-growing audience from central government policy teams at both senior and advisory levels. These sessions provide an easy, relaxed opportunity to discuss completed work, and generate interest in future projects and dissemination opportunities.

Topics covered this year include Māori cultural values for fresh water, the use of one of our Nationally Significant Databases and Collections to help identify Psa, land use change and surveys on land owner behaviour, collaborative processes to set environmental limits, computer gaming to engage communities in pest control, 'big' environmental data and a mini-series for ecosystems services topics. These events were hosted by MPI, MfE, DOC and the National Library.

### Workshops, newsletters, videos

We organised a wide range of workshops for stakeholders and end-users in the wider community. The most significant of these workshops were training in biocontrol of weeds techniques and identifications, pest management ('Biosecurity Bonanza'), grass species identification, quantifying and valuing ecosystem services, forest management approaches to mitigate risk of post-harvest landslides, and organising the annual Sanctuaries of New Zealand conference and workshop.

We produced 12 different newsletter series (print or e-newsletters). Each focuses on the needs of particular client, stakeholder and end-user groups. These newsletters are received very positively.

Short informative video clips are another engaging way to present topical science. On our YouTube channel ([www.youtube.com/landcareresearch](http://www.youtube.com/landcareresearch)), video clips are listed under our four National Outcomes and 12 playlists. In addition, we contribute scientific knowledge transfer to videos produced by AHB/TBfree New Zealand and DOC.

## Key Performance Indicators

- MBIE's external Stakeholder Survey found that 95% of respondents for Landcare Research had adopted knowledge or technology from Landcare Research in the past three years (97% in the previous survey)
- 92% of respondents are satisfied with their experience of accessing knowledge or technology from Landcare Research (93% in the previous survey)

<i>For the year ended 30 June:</i>	2010	2011	2012	2013
<b>Knowledge transfer</b>				
New or improved products, processes & services	70	80	73	64
Contract reports	185	190	144	141 <sup>1</sup>
Conference presentations	222	287	279	292
Publications on technical information & research results	349	374	371	277 <sup>2</sup>
Science presentations to stakeholders & community groups	220	271	259	229
Staff invited to participate in stakeholder meetings or workshops	193	281	259	237 <sup>1</sup>
Staff invited onto national advisory groups	41	38	61	60
<b>Business development &amp; commercialisation</b>				
Patents granted	1	1	0	1
Licensing arrangements	2	2	1	2
Joint ventures	1	1	3	2
Spinoff companies formed	0	0	1 <sup>3</sup>	0 <sup>4</sup>

<sup>1</sup> In addition, we provided a further 313 progress reports to clients.

<sup>2</sup> Decrease due to fewer published conference presentations being recorded although staff made as many presentations as in previous years. Fewer book chapters were also published.

<sup>3</sup> carboNZero Holdings commenced operating as our fully-owned subsidiary company on 1 July 2012. (Sirtrack was sold during 2011/12.)

<sup>4</sup> On 1 July 2013, carboNZero Holdings and the Enviro-Mark Programme were merged to become Enviro-Mark Solutions Limited.



# OUR ORGANISATION



People are the lifeblood of our organisation. We strive to encourage our staff in the pursuit of knowledge and innovative research, and to provide a safe, stimulating working environment that supports our wider social and ethical responsibilities. Landcare Research is committed to good employer practices and equal employment opportunities for all staff regardless of role, age, ethnicity, gender, sexual orientation or (dis)ability.

Our investments in infrastructure ensure staff have excellent office and laboratory facilities and that important assets (such as our biological collections) are better protected. We have a culture of collaboration and are part of several pan-CRI initiatives to improve workforce planning. In procurement, we make significant use of All-of-Government contracts, pan-CRI contracts and syndicated contracts to broker excellent service and supply contracts, greater IT benefits, and more sustainable options for both procurement and waste management.

Landcare Research has a long-standing reputation for corporate sustainability performance and transparent public reporting. We publish on our website detailed accounts and data of our performance, updated annually. These web pages cover the seven elements required by the New Zealand Human Rights Commission, set high standards for environmental reporting, discuss ethics and science issues from a sustainability perspective, and identify Māori values for sustainability reporting.

[www.landcareresearch.co.nz/sustainability](http://www.landcareresearch.co.nz/sustainability)

## Certifications and partnerships

We have:

- ISO 14001 certification for our environmental management system and practices
- Tertiary accreditation (the highest level) in the Accident Compensation Commission's programme for Workplace Safety Management Practices
- carboNZero<sup>Cert™</sup> certification of our carbon-neutrality

## We are members of:

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

## We are supporters of:

- The Public Service Association's Partnerships for Quality approach
- The Mainstream Programme (Ministry of Social Development) by providing training and work experience to people with significant disabilities to help them get employment
- Workbridge



## People

### GOAL

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

The external market for talented researchers is changing rapidly, with top talent globally mobile and highly sought after, particularly in the environmental sciences. The situation is also exacerbated by the increasingly tough funding environment in New Zealand and greater opportunities with higher remuneration in Australia enticing many talented New Zealand researchers to cross the Tasman. Our science facilities, culture and our philosophy of *manaaki tangata – manaaki whenua* play vital roles in attracting and retaining staff.

Many of our Lincoln-based staff continue to struggle with private insurance and EQC claims after the 2010 and 2011 earthquakes. We provide support and allow flexibility to deal with the many and varied aspects of this ongoing, stressful process.

We manage our capability within seven science teams that report to the Chief Scientist. These science teams are the long-term collegial 'home' for staff where they are able to develop skills and experience, plan career paths, and develop new ideas. The Chief Scientist and Science Team Leaders service the changing capability and capacity needs of the Portfolios. Where potential gaps are identified, we address these through partnering with other research providers in New Zealand and offshore; recruiting new staff with the required expertise; and enabling our staff to develop new capabilities.

### Capability review

The latter part of our financial year has been dominated by work being undertaken by the Capability Work Stream led by the Chief Scientist and General Manager, People and Culture. The role of the work stream is to recommend how best to refocus our capability to match the changes that have occurred in the revenue generated from our stakeholders, and to ensure we are fit for purpose. We are ensuring that we retain critical capability and are positioning ourselves to be able to respond to new opportunities, but part of this process has involved the disestablishment of some roles across both science and support. The majority of this has been achieved through voluntary redundancies and we have been able to retain institutional knowledge through the appointments of some of the more senior staff to Research Associate positions. In addition to this process we have had a strict policy around replacement of positions resulting from resignations, ensuring investment in key growth areas while reducing capacity in other areas of science where, while critical and need to be maintained, future opportunities remain more static.

The Capability Work Stream is working in conjunction with work streams on Cost Management and Revenue Opportunities.

### Training and development

Reduced Government funding and the resulting focus on ever-increasing fiscal prudence has meant a decrease in resources available for staff development and a need to be selective about where we do invest. We do, however, look for continued and creative ways around this through greater internal mentoring and coaching, and internal development programmes to build resilience in managerial expertise and leadership, and to develop our bicultural capabilities. This year we funded five technicians through our \$5000 study grant (plus some assistance from science team budgets) to undertake specialist external training that otherwise would be unavailable.

This year, our Manaaki Whenua Fellowship was shared between two staff enabling them to develop links with two high-profile overseas research organisations to further their research and benefit New Zealand. We are also committed to continuing our support for early-career scientists on postdoctoral fellowships. This year we hosted 16, two of whom commenced during the year.

We spent \$1363 per FTE (equivalent to 1.83% of our payroll) on direct training, which includes conferences,

training courses and further postgraduate study for our staff (but excludes travel allowances).

We support two First Foundation Scholars: one is now in his second year studying Forestry at the University of Canterbury and achieving great results; the other is in his final year at high school.

#### Working with our union

A joint remuneration working party with representatives from management and the Public Service Association (PSA), the voluntary trade union representing staff, reviewed our remuneration and profit share policies. This involved considerable teamwork over a period of almost a year. The process was successful in redesigning our science remuneration bands and developing transparent remuneration bands for our support staff. We also updated our profit share policy including making it more transparent and limiting eligibility for this at senior levels.

Our Collective Employment Agreement (CEA) was effectively 'rolled over' for a three-year term with only minor administrative amendments and very conservative approaches to remuneration increases for the 2013/14 and 2014/15 financial years – agreed with the support of our PSA delegates and members.

#### Equal employment opportunities (EEO)

Our continued commitment to EEO principles has been demonstrated through a number of initiatives including the appointment of a Kaihautū to the Senior Leadership Team, increased investment in tier three Māori capability and continuing to provide site-based Te Reo, Tikanga Māori and Treaty of Waitangi training.

Gender equity in our leadership team and tier three leaders is evident in both structure and remuneration. All roles have been brought into alignment from a remuneration perspective and recent recruitments have ensured an equitable gender balance.

We continue to support the Mainstream Programme – this year, a partially-sighted employee joined our Allan Herbarium team. More recently, we provided a blind science graduate, who approached us through Workbridge, with shorter-term work experience mentored by one of our senior botanists.

#### Pan-CRI collaboration

We continue to support and participate in the pan-CRI human resources initiatives and are working on the

implementation of a shared recruitment website that would enable operational savings and consistent use of recruitment technology. The National Science Challenges and the Lincoln-based Productive Land Innovation Hub will create opportunities for greater inter-organisational collaboration for both science and support staff and will provide a more attractive environment for experienced scientists and graduates both nationally and internationally.

#### Health & Safety (H&S)

During the year, the Board of Directors oversaw a review of our H&S performance, procedures and policies, with a particular focus on key risk areas. Fieldwork continues to present the most wide-ranging and significant hazards for staff and subcontractors. Because of this complexity, we hold annual field forums to discuss emergency responses plus other important H&S issues for field staff.

This year, we also conducted a series of gradual-process injury prevention workshops at three of our major worksites. These focused on preventing and self-managing symptoms of muscle tension commonly experienced by desk staff. We continued our focus on encouraging 'early reports' of symptoms to enable immediate mitigation steps.

In consultation with employees we developed a Drug and Alcohol Policy this year and we substantially overhauled our existing Company Vehicle Policy.

Soil scientists from across Landcare Research getting together for a training and development workshop  
Les Basher



## Key Performance Indicators

### Leadership, engagement and organisational culture:

- 71% of our staff took part in the staff engagement survey – this is well above the CRI average. The results demonstrate the passion and commitment our staff have to our organisation and our Core Purpose. Despite a significant restructuring of our science framework, levels of engagement remained stable; this highlights the strength of our culture.
- Members of the Senior Leadership Team participated in individual development initiatives with one member attending a 9-month programme with Leadership New Zealand.
- The developmental focus for tier 3 and 4 managers has been on managing non-performance of staff; formal programmes will follow the success of the pilot programme.

### Talent management:

All support and science teams have capability plans in place.

#### Good employer:

- Our performance is reported comprehensively online at [www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress/our-people](http://www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress/our-people)
- H&S; Wellness; EEO; gender, age, length of service and pay equity; commitment to Treaty obligations; labour relations and diversity are covered under Good Employer at [www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress/our-people/good-employer](http://www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress/our-people/good-employer)
- Our support for the Mainstream Programme, Superannuation and student loan repayments are covered under Social Responsibility at [www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress/our-people/social-responsibility](http://www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress/our-people/social-responsibility)
- Our subsidiary carboNZero Holdings Ltd followed the same policies and procedures as the parent company.

### Human resources

<i>For the year ending 30 June:</i>	2010	2011	2012	2013
Total staff (FTEs) in Landcare Research	377	379	356	329
In science teams	263	261	250	232
- With post-graduate qualifications (HC)	210	210	195	180 <sup>1</sup>
In science support	43	45	44	42
In general support	71	73	62	55
carboNZero Holdings (subsidiary) staff	-	-	19	12 <sup>2</sup>
Women (% science team staff)	36.1%	37.6%	38.4%	32.8%
Women recruited (% science team staff recruited)	38.1%	62.5%	48%	53.8%
Māori science staff (HC)	10	9	8	8
Days sick leave (self or for family dependant)	5.5	4.5	4.4	4.8
Lost-time injuries	3	1	1	1
Days lost per lost-time injury	1.7	1.8	40.6 <sup>3</sup>	7 <sup>4</sup>
Staff turnover (based on HC)	9.2%	14.7%	11.5%	16.1% <sup>5</sup>
Turnover of key senior scientists	0	3.4%	8.6% <sup>5</sup>	5.9% <sup>6</sup>

1. In addition, 24 science support staff and 12 general support staff have post-graduate qualifications
2. Does not include Enviro-Mark staff who joined with carboNZero Holdings staff to form a new subsidiary on 1 July 2013
3. A fall from a ladder when standard procedures were not followed. The injured staff member is now a fully recovered
4. One lost time event relating to an open wound to the leg; inadequate medical advice delayed recovery. Lost-time injuries per million hours worked = 1.4 (includes injuries where only a part day was lost)

5. Turnover of science staff = 13.7%; science support = 8.9%; general support = 31.1%. Turnover includes a programme of voluntary and mandatory redundancies (9 staff). (Another 8 staff redundancies occurred in early 2013/14.)
6. Key senior scientist = Band 6, Science Team Leader or Science GM. The only reduction in resource for key staff included a reduction in hours for one of our principal scientists.

FTE = full-time equivalent

HC = head count



## Infrastructure

### GOAL

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

Our investments in science infrastructure are aligned to our Statement of Core Purpose, Outcomes and Impacts, and so have inherent benefit to New Zealand. Our investment in NeSI is covered in the Informatics section (page 44).

#### The Beaver Plant Pathogen Facility

The most significant investment project completed this year was our new 'state of the art' plant pathogen and invertebrate transitional and containment facility in Auckland; it was opened in November 2012. The facility is the only one of its kind in New Zealand. It removes our dependence on overseas facilities to complete work on plant pathogens, and will allow new projects to be undertaken. For example, the Brazilian yellow leaf spot fungus is a potential biocontrol agent for *Tradescantia*, but as Brazil has no pathogen containment facilities, it has never been possible to obtain safe, clean isolates needed for release. As well as weed biocontrol studies, the facility is also suitable for safely undertaking research into exotic plant pathogens that pose a threat to native flora (e.g. kauri dieback PTA) and the primary sector (e.g. kiwifruit Psa bacterium).

Our staff make significant contributions to the design of specialist facilities such as this one. Their input ensures the infrastructure is truly fit for purpose and able to meet future needs. Where possible (within the constraints of containment requirements) facilities comply with our sustainability principles, e.g. energy and water efficiency and environmentally-friendly fit-out.

#### Laboratory equipment

We purchased and installed three significant pieces of laboratory equipment. A genetic analyser replacement for our EcoGene® laboratory supports new services and enables increased throughput. A LECO Analyser supports the high volume of carbon and nitrogen analyses for our Environmental Chemistry Laboratory. And a reverse osmosis water system supplies ultra-pure water to our laboratories at Lincoln.

#### Emergency generators for business continuity

We installed a new generator to extend the emergency power capacity at our Lincoln site, particularly to laboratories, the Greenhouse Gas Research and Invertebrate Containment facilities, and computer servers. As well as significantly reducing business continuity risks, the new generator improves our capacity to meet/offset expensive winter peak-demand electricity pricing at our largest site. Lincoln's 'old' generator will be relocated in August 2013 to our Hamilton site.

#### Building upgrades to protect assets

As part of our programme of works to upgrade archival conditions to help protect our nationally significant biological collections, we invested in improved climate control (humidity and temperature conditions) in the Auckland site's collection vaults. We also improved the refrigeration and alarm systems.

#### IT upgrades

We improved WiFi services across all Landcare Research offices to near 100% access for staff and visitors. We redesigned our Wide Area Network (WAN) providing a second Internet gateway at Palmerston North to improve performance and disaster recovery resilience (mitigating business continuity risks). We moved to REANNZ (Research and Education Advanced Network New Zealand) as our Internet service provider to improve service for staff and reduce costs for the company.

Microsoft Lync was made available to all staff for desktop video conferencing within Landcare Research and externally. Uptake of Lync has been excellent with staff readily adapting to the new way of 'face-to-face' communicating and working together on documents.

## Procurement & Environmental Performance

### GOAL

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

We are committed to increasing the efficiency and sustainability of our procurement practices, and to minimising and mitigating the adverse effects of our activities on the environment. We report comprehensively on this via our sustainability web pages ([www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress](http://www.landcareresearch.co.nz/about/sustainability/our-sustainability-progress)).

#### Our environmental performance

We maintain ISO 14001 environmental certification and carboNZero<sup>Cert</sup>™ certification (verified by AsureQuality) – both highlight our commitment to best practice.

We also monitor our performance against the Sustainable Business Council KPIs. We strive for continual improvement

in our environmental performance and so set stretch targets, which are to improve on the rolling average across the previous five years or improve on the previous year's performance if that is better than the 5-year rolling average.

A particularly noteworthy achievement was an 11.3% reduction in total greenhouse gas emissions compared to 2011/12; 2011/12 emissions were 12.7% less than in 2010/11. Increased monitoring and management of travel and energy use have been key to this achievement.

#### Collaborative procurement

We continue to collaborate with other CRIs and AsureQuality through the CRI Procurement Forum, and to support All of Government (AoG) initiatives. This year we benefitted from AoG procurement initiatives that were extended to include mobile voice and data, legal and recruitment services and electricity supply contracts. The Tahi Mobile AoG agreement will realise good ongoing operational savings for mobile data, calling and texts. Our AoG agreement for printing and copying enabled Follow-You Printing<sup>®</sup> to be enabled at our four main sites to reduce waste, allow staff to print anywhere and ensure privacy. This initiative has already demonstrated a reduction in paper usage and estimated operational cost savings of approximately \$2000 per annum.

#### Environmental performance (Landcare Research parent only)

For the year ended 30 June:	2010	2011	2012	2013
Motor vehicle (km/FTE)	1,138	1,660	1689	1181
Domestic air travel (km/FTE)	4,715	5,634	4,723	3989
International air travel (km/FTE)	9,738	12,224	7,756	7645
Total energy (KWh/FTE)	9,489	8,824	6504	6108
Imputed CO <sub>2</sub> (tonnes)	2,611	2,656	2,318	2056
CO <sub>2</sub> offsets purchased	2,825	2,679	2318	2200 <sup>1</sup>
Avoidable waste to landfill (kg/FTE)	1.25	2.12	2.52	1.93
Water used (litres/FTE)	27,013	29,743	18,758	17,817
Native animals killed through by-catch	0	21	0	1

<sup>1</sup> Landcare Research pre-purchased a total of 2200 carbon credits (BHL Biogas Kinauni) through the carboNZero programme in June 2013.

Staff sorting waste during a biannual skip audit Cissy Pan

The CRI forum is leading a large procurement project to achieve a syndicated contract for supplying lab consumables to CRIs, district health boards and universities. The project is due for completion in November 2013 and is expected to deliver significant savings.

**Accidental by-catch of native animals**

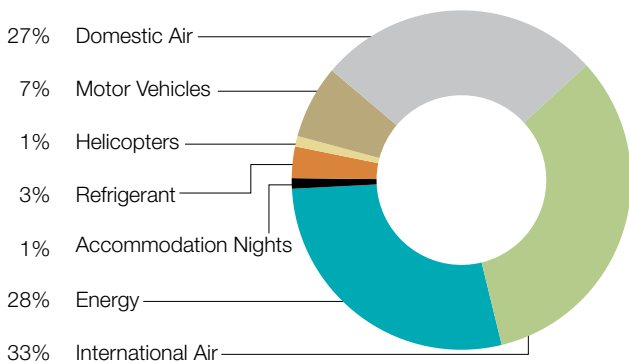
In 13 projects involving routine trapping of pests, 8533 target animals were caught, largely because of one project that involved intensive and recurring possum trapping. During this routine trapping, 270 non-target animals (3% of total captures) were caught – only two of these were native (two inshore seabirds caught as part of a kiore monitoring programme, one of which was released but the other had to be humanely killed).

**Compliance**

Our operations are subject to a broad range of legislation covering environmental, good employer (including EEO and Health & Safety), human rights, ethical and financial issues. There were no material instances of non-compliance in 2012/13.



Source of our greenhouse gas emissions (2056 t CO<sub>2</sub>e)



We produced 38.2 t CO<sub>2</sub>e/\$m revenue



# Summary of Financial Performance

## Summary of group financial performance

For year ended 30 June:	2011	2012	2013	2013	2014
	Achieved	Achieved	Target	Achieved	Target
Revenue, \$m	63.4	58.4 <sup>1</sup>	59.0	55.5	55.7
EBIT before investment, \$m	3.9	3.3	3.3	2.2	2.2
EBIT, \$m	2.9	2.2 <sup>2</sup>	1.6	0.8	1.5
Investment, \$m	1.0	1.2	1.8	1.4	0.7
Total assets, \$m	50.9	45.3	43.6	45.5	43.3
Return on equity	8.4% <sup>3</sup>	4.9%	4.2%	4.1% <sup>3</sup>	3.5%
Dividend \$m	0.7	1.1	-	-	-
Equity ratio	52%	56%	63% <sup>4</sup>	61%	65% <sup>4</sup>
Gearing	13%	0%	0%	0%	0%
Interest cover	31	47	101 <sup>5</sup>	80	36

<sup>1</sup> 2012 Revenue achieved excludes Sirtrack, which was disclosed as a discontinued operation due to the sale of the business in November 2011.

<sup>2</sup> 2012 EBIT achieved excludes Sirtrack as this was disclosed as a discontinued operation as a result of the sale of the business in November 2011.

<sup>3</sup> 2011 and 2013 Return on equity excludes extraordinary restructuring costs.

<sup>4</sup> 2013 and 2014 Equity ratio target has been adjusted to calculate on averages rather than closing values (original SCI target 2013:64.1% and 2014 66.5%)

<sup>5</sup> 2013 Interest cover target has been adjusted to calculate on EBITDAF rather than EBIT (original SCI target 28.3)

### Revenue:

Includes science research, subsidiaries, contract work for government and commercial clients, royalties, licence fees plus income from the sale of product and the lease of assets. It excludes income from gain on sale of subsidiaries and interest on investments and from finance leases, \$0.1m for 2013 (2012: \$0.9m).

### EBIT:

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

### Return on equity:

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

### Equity ratio:

Average shareholders' funds ÷ average total assets.

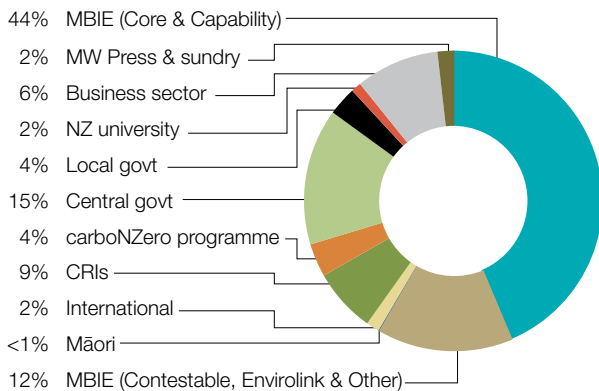
### Gearing:

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

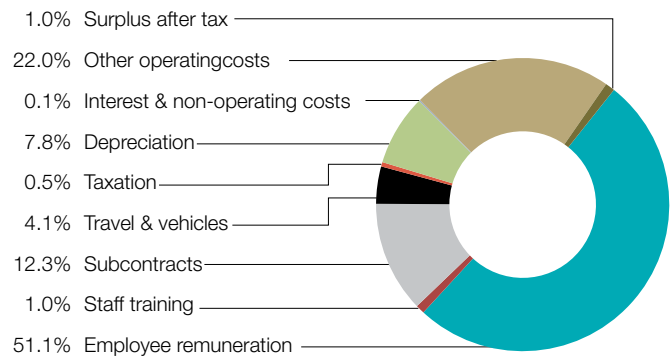
### Interest cover:

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

Revenue by Source



Where our revenue goes



### Where our revenue comes from

- Ministry of Business, Innovation and Employment's (MBIE) Science + Innovation Group Core funding 44% – includes capability funding to maintain existing skill and to develop new science capability
- MBIE contestable funding sources 12%
- International 2% – development projects funded by donor agencies, international consultancy projects
- CRIs 9% – research subcontracted to us in collaborative programmes
- The carboNZero programme<sup>Cert™</sup> 4% – which provides certification services for greenhouse gas reduction and mitigation
- Central government 15% – services contracted by government departments including DOC, MfE and MPI
- Local government 4% – contracted work for regional, district and city councils
- Universities 2% – contracted services, some paid lecturing by our staff, and rentals for university staff located in our buildings
- Private & business sector 6% – principally contracted work for businesses and industry organisations
- MW Press & sundry 2% – Manaaki Whenua Press is our natural history and science book publishing and retailing business centre

### Where our revenue goes

- Employee remuneration 51.1% – includes staff in management, science, support roles, business development and carboNZero Holdings
- Staff training 1.0% – includes conferences, training courses and support for postgraduate study (2.49% of the total payroll)
- Subcontracts 12.3% – research subcontracted to other research providers, including CRIs and universities in collaborative research programmes
- Travel & vehicles 4.1% – 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
- Depreciation 7.8% – includes accounting depreciation on buildings, science equipment and computers
- Other operating costs 22% – includes electricity, carbon credits, software licences, insurance, consumables, and lease costs

# Directory

## DIRECTORS

Peter M Schuyt (Chair)  
 Dr Chris Downs  
 Gavan Herlihy  
 Hon. M John F Luxton QSO  
 Professor Emily Parker  
 Tania J Simpson (Deputy Chair)  
 Victoria A Taylor

## CORPORATE (REGISTERED) OFFICE

Canterbury Agriculture & Science Centre  
 Gerald Street  
 PO Box 69040  
 Lincoln 7640  
 New Zealand

**Phone** +64 3 321 9999  
**Fax** +64 3 321 9998

## WEBSITE

[www.landcareresearch.co.nz](http://www.landcareresearch.co.nz)

## SENIOR LEADERSHIP TEAM

Dr Richard Gordon	Chief Executive
Carol Bellette	Chief Financial Officer and Company Secretary
Justine Daw	General Manager, Science & Policy
Katrina Direen	General Manager, People & Culture
Dr Libby Harrison	General Manager, Development (resigned 30 Sep 2013)
Dr Phil Hart	General Manager, Science Investment & Evaluation
Rau Kirikiri	Kaihautū (part time)
Dr Peter Millard	General Manager, Science & Industry
Dr David Whitehead	Chief Scientist

**Email** <surname><initial>@landcareresearch.co.nz

## BANKERS:

ANZ Bank New Zealand Limited

## AUDITORS:

Audit New Zealand on behalf of the Auditor-General

## SOLICITORS:

Buddle Findlay

## ALEXANDRA

43 Dunstan Road  
 PO Box 282  
 Alexandra 9340

Ph: (03) 440 2930  
 Fax: (03) 440 2931

## AUCKLAND

231 Morrin Rd, St Johns  
 Private Bag 92170  
 Auckland 1142

Ph: (09) 574 4100  
 Fax: (09) 574 410

## DUNEDIN

764 Cumberland Street  
 Private Bag 1930  
 Dunedin 9054

Ph: (03) 470 7200  
 Fax: (03) 470 7201

## LINCOLN

Gerald Street  
 PO Box 69040  
 Lincoln 7640

Ph: (03) 321 9999  
 Fax: (03) 321 9998

## GISBORNE

ZG FM Building  
 Grey Street  
 PO Box 445  
 Gisborne 4040

Ph: (06) 863 1345  
 Fax: (06) 863 1346

## HAMILTON

Gate 10  
 Silverdale Road  
 Private Bag 3127  
 Hamilton 3240

Ph: (07) 859 3700  
 Fax: (07) 859 3701

## WELLINGTON

Level 14, Prime Property Tower  
 86-90 Lambton Quay  
 PO Box 10345  
 Wellington 6143

Ph: (04) 382 6649  
 Fax: (04) 913 9977

## NELSON

First Floor  
 24 Nile Street  
 Private Bag 6  
 Nelson 7042

Ph: (03) 545 7700  
 Fax: (03) 545 7701

## PALMERSTON NORTH

Riddet Road, Massey  
 University Campus  
 Private Bag 11052  
 Palmerston North 4442

Ph: (06) 353 4800  
 Fax: (06) 353 4801

## ENVIRO-MARK SOLUTIONS LIMITED

Dr Ann Smith (CEO)  
 Suite 1, Level 2  
 20 Augustus Terrace  
 PO Box 137182  
 Parnell 1151, Auckland

Ph: (09) 574 4152

(Registered Office)  
 Gerald Street  
 PO Box 69040  
 Lincoln 7640

Ph: (03) 321 9999  
 Fax: (03) 321 9998



## GLOSSARY

AHB	Animal Health Board, now TBfree New Zealand, which is a part of OSPRI
BusinessNZ	New Zealand's largest advocacy group for enterprise
CABI	CABI is a not-for-profit international organisation that improves people's lives by providing information and applying scientific expertise to solve problems in agriculture and the environment.
CEMARS	Certified Emissions Measurement and Reduction Scheme
CRC	Cooperative Research Centre (Australia)
CRI	Crown research institute
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DairyNZ	DairyNZ is the 'industry good' organisation, representing New Zealand's dairy farmers
DCD	Dicyandiamide, a nitrification inhibitor
DNDC	Denitrification-decomposition computer simulation model
DOC	Department of Conservation
Ecosystem services	The 'free' services that healthy ecosystems provide e.g. clean water, fertile soil, storm water retention, erosion prevention
Environmental limits	The point at which ecosystem services collapse, e.g. the soil's biological community is depleted to the extent that they can no longer replenish nutrients
<i>E. coli</i>	<i>Escherichia coli</i> , a bacterium commonly found in the lower intestine of mammals
EQC	Earthquake Commission
FAO	Food and Agriculture Organisation of the United Nations
Kaitiakitanga	Traditional guardianship of natural resources
KPI	Key performance indicator
LCDB	Land cover database
LINZ	Land Information New Zealand
Mātauranga	Traditional cultural knowledge
MBIE	Ministry of Business, Innovation and Employment
MFAT	Ministry of Foreign Affairs and Trade
MfE	Ministry for the Environment
MPI	Ministry for Primary Industries
NGO	Non-governmental organisation
NLRC	National Land Resource Centre
OSPRI	Operational Solutions for Primary Industries, comprised of the TBfree New Zealand and the National Animal Identification and Tracing programmes
S-map	Digital soil map for New Zealand
TB	Tuberculosis
TFBIS	Terrestrial and Freshwater Biodiversity Information System
TPK	Te Puni Kōkiri
UNFCCC	United Nations Framework Convention on Climate Change
ZESPRI	The kiwifruit marketing board (not an acronym)
<b>Chemical symbols</b>	
C	Carbon
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon dioxide
CO <sub>2</sub> e	Carbon dioxide equivalent
N	Nitrogen
NH <sub>3</sub>	Ammonia
N <sub>2</sub> O	Nitrous oxide
P	Phosphorous

Annual Report

2013 Part One



Landcare Research  
Manaaki Whenua