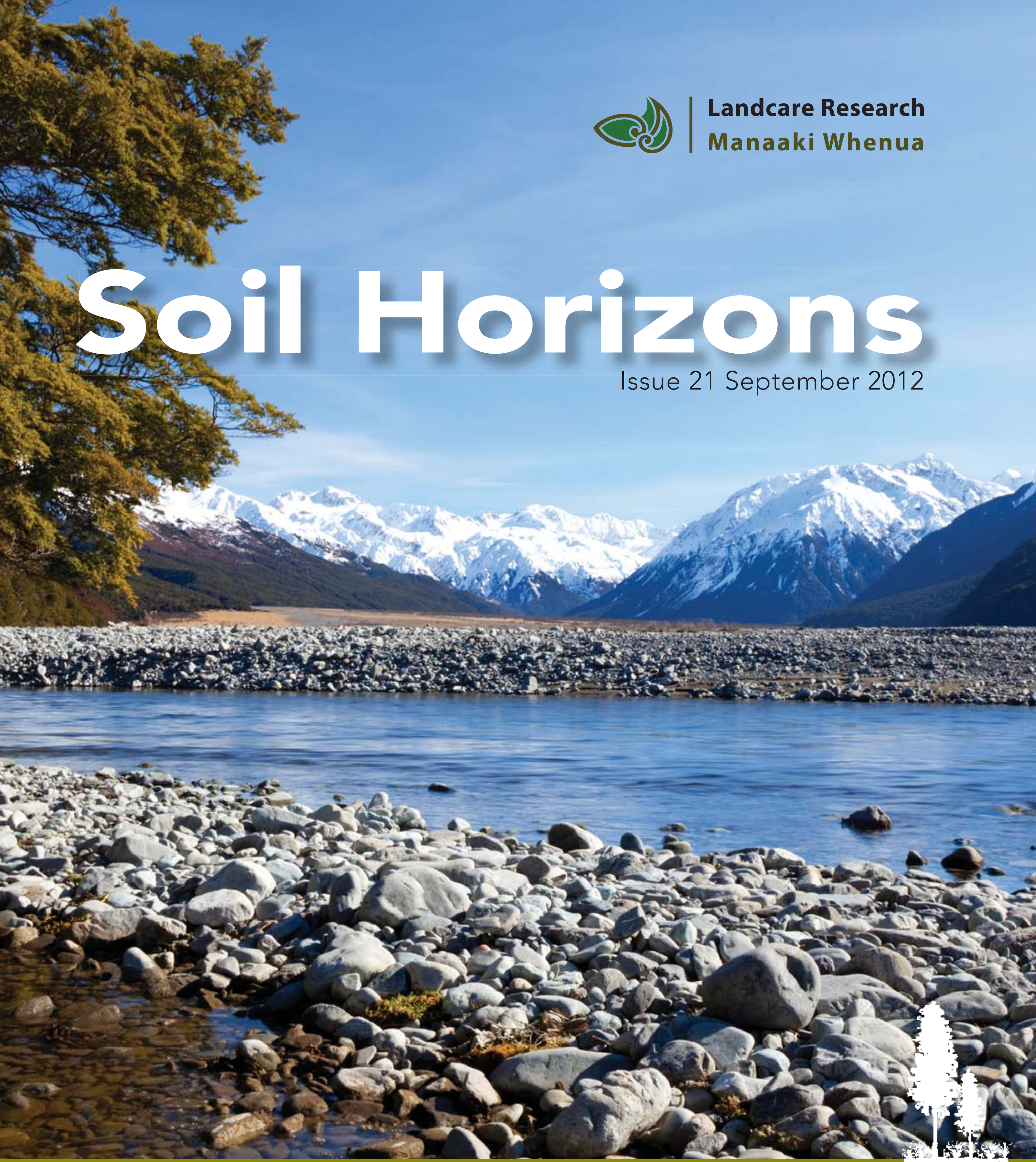
Landcare Research
Manaaki Whenua

Soil Horizons

Issue 21 September 2012



Introducing:

THE NATIONAL LAND RESOURCE CENTRE

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In this Issue

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Editorial

I am pleased to use this opportunity to highlight the breadth of our activities in soil physics, chemistry and biology and to emphasise that we are committed to maintaining and building this capability to support our research.

Landcare Research's Core Purpose is to drive innovation in New Zealand's management of terrestrial biodiversity and land resources to protect and enhance our terrestrial environment and grow New Zealand's prosperity. Achieving the sustainable use of land resources and ecosystems services at catchment scales is a critical outcome of our work and we are recognised as the leading Crown Research Institute in soil characterisation, spatial land information that integrates across sectors and scales, and greenhouse gas inventory from terrestrial systems.

With the implementation of new science frameworks and Core Funding we are more responsible for allocating our research effort to match stakeholder needs and contribute to national outcomes. Our 280 scientists across 9 locations are organised in 7 Science Teams comprising groups of people with similar specialist skills. The second dimension is 10 Portfolios where researchers allocated from Science Teams are funded to do the research, ensure relevance to stakeholder needs, and contribute to achieving national outcomes.

Soil science research is distributed widely across our Portfolios but is particularly relevant for our Characterising Land Resources, Realising Land's Potential, Understanding Ecosystem Services & Limits, and Measuring Greenhouse Gases & Carbon Storage Portfolios. To sustain our agricultural industries and reduce our environmental impacts, we recognise the urgent need to guard the integrity of our soils. The term 'soil security' is emerging to describe the need to manage the natural capital of our soils to underpin food security and fresh water conservation, reducing contamination and enhancing biodiversity as well as abating greenhouse gas emissions. Soil carbon is a critical component of soil quality and we work with a range of methodologies to reduce errors in the measurement and mapping of soil carbon, and to investigate the processes that regulate changes in relation to land use and management. We also recognise the inseparable linkages between soil, water, and nutrients.

This issue contains updates on the contributions of soil science to a wide range of critical issues, including water quality, reducing contamination with biowastes, ecosystem services and the natural capital of soil, the importance of clay in establishing soil carbon, and processes of nitrogen transformation in soils that regulate greenhouse gas emissions and ammonia emissions. Of special significance is the announcement and recent launch of the National Land Resource Centre, a new initiative led by us but embracing collaborative research activity. The launch of the NLRC provides a window into the future of shared accessibility of data and their interpretation to address the far-ranging needs of the land sector to ensure New Zealand's prosperity.

DAVID WHITEHEAD
Chief Scientist. Landcare Research

The launch of the National Land Resource Centre

The recent launch at Te Papa in Wellington of the National Land Resource Centre (NLRC) heralded a science-backed national initiative to improve the way science is used to enhance one of the country's most important assets – the land.

Initiated by Landcare Research, the National Land Resources Centre (www.nlrc.org.nz) will be a 'one stop shop' for providing information for policy, business and science, coordinating engagement and foresight into future issues, as well as undertaking capacity building.

New Zealand's 'land economy' – agriculture, forestry, mining and tourism – provides more than 25% of the country's GDP and our future prosperity is therefore highly dependent on better understanding and managing this important asset.

The science of the land resource seemed the perfect place to seek transformation. A new approach to the way we produce and use research could make a significant impact – not just looking at today's issues but providing strategic leadership as we consider tomorrow's challenges and the science that might be needed to respond to them.

The NLRC's development is in response to the Crown Research Institute's Taskforce recommendations that included calls for a more collaborative approach to solving national science challenges and a focus on creating maximum research uptake, and therefore impact, by working strategically and in partnership with all stakeholders.

The NLRC has three main aims that have been developed in conjunction with stakeholders:

- Engagement with all those interested in the land resource by providing a gateway into available research and resources, workshops, forums and best teams
- Access to best available, easily consumable and fit-for-purpose information for policy, business and science users – for today and tomorrow's New Zealand
- National capability building to lift performance for those researching, governing and managing the land resource

The Hon. Steven Joyce, Minister of Science and Innovation, said the establishment of the Centre signalled an exciting new era for soil and land research by linking together the science community and end-users. "Improving access to high quality land and soil knowledge will enable better management of our land resources. The Centre is also enabling agencies and organisations to easily share land management information, encouraging greater collaboration and coordination in this area."

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PLEASE CONTRIBUTE TO The National Land Resource Centre: Professional Development Survey

NATIONAL LAND RESOURCE CENTRE™

The National Land Resource Centre (NLRC) aims to improve national science capability in soil and land resource sciences. To do this the Centre will provide on-going training and professional development opportunities. These opportunities will be designed for (but not limited to) professionals and land managers who wish to keep up-to-date with information provision, and to maintain high professional standards in the soil and land resource sciences, but have limited time due to professional commitments. Our first step is to scope professional training needs that the Centre could address.

The NLRC is therefore conducting a short survey of the types of courses and training that are available in each of the land resource sciences, and also those that are needed.

To complete the survey please go to **https://www.surveymonkey.com/s/nlrctrainingsurvey**. Alternatively, you can provide feedback by visiting this website **www.nlrc.org.nz**. Survey closes on October 26th 2012.

For further queries or comments please contact **Dr Emily Weeks at resources@nlrc.org.nz.**

Soil natural capital

The recognition of soil as a component of the earth's natural capital creates new avenues for integration of soil science with other environmental sciences, and with economics. Soil natural capital has emerged as a useful concept to analyse environmental and resource management problems, and although soil science provides an understanding of the links between soil properties and processes, soil natural capital provides the key to putting a real value on soils and the many services they provide to society.

The concept of soil natural capital helps convey the value of soil services to communities and policymakers, making the discipline of soil science relevant to current political decision-making timescales. It potentially enables the "greening" of existing economic indicators such as GDP (Gross Domestic Product), which at present ignore impacts on human well-being such as flood control and nutrient filtering. Recently, researchers have begun to reveal relationships between soil natural capital, soil properties, processes and the provisioning and regulating of services provided by soils.[1,2]

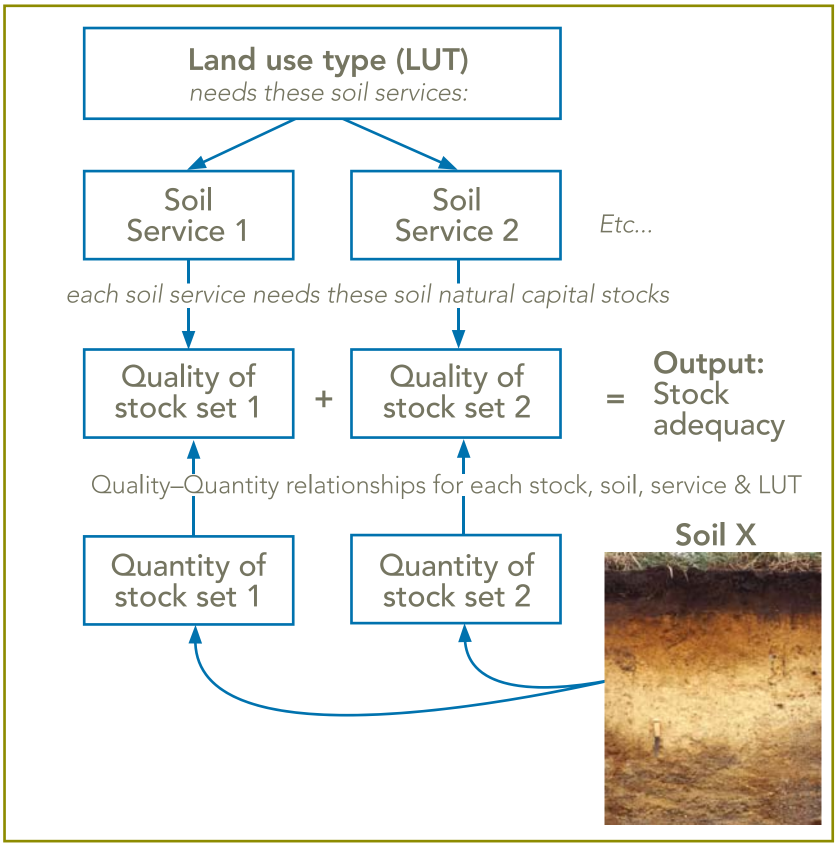

FIGURE 1 Outline of procedure for evaluating soil natural capital (SNC) for a specified soil and land use type.

We are developing a method to estimate and map soil natural capital using commonly available soil information. We define the soil natural capital "stocks" by soil properties that can be either directly or indirectly measured or estimated within a soil profile, facilitating the mapping of soil natural capital stocks, using normal soil mapping techniques.

There are four kinds of soil stocks: inherent stocks (e.g. clay content); manageable dynamic stocks (e.g. soil water content); energy stocks (e.g. stored heat); soil fabric (e.g. total porosity).

Our "stock adequacy" method quantifies soil natural capital relative to the requirements of a specified land-use type. We propose that for adequate sustainable production, a land-use type requires a specific set of soil services, which need to draw on a specific set and level of soil stocks. If these stocks are adequate then the soil services can operate to their full potential, and in turn, the land-use type can operate to its potential, as far as the soil is concerned. If the soil stocks are not adequate then the provision of soil services, and in turn the land-use type, will not perform adequately.

The stock adequacy method has the following steps (outlined in Figure 1).

1 Define the land-use type.
2 Select the soil services required.
3 Determine the soil stocks, represented by soil properties, needed to sustain each soil service.
4 Quantify the soil stocks.
5 Estimate the quality of each stock to adequately support a specified level of soil service in a percentage scale.
6 Define stock quantity–quality curves.
7 Derive an aggregated stock adequacy across all stocks.

Because quantification of soil natural capital has many valuable applications, e.g. applied to resource-use efficiency, and land-use trade-off analysis, we are continuing to develop this method.

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(1) Dominati et al. (2010) *Ecological Economics* 69: 1858–1868
(2) Robinson et al. (2011) *Vadose Zone J.* doi:10.2136/vzj2011.0051

“Space shuttles” measuring ammonia emissions from cattle excreta!

Gaseous ammonia is generated at the soil surface, following the application of any source of nitrogen that also induces an increase in soil-surface pH. The main such sources are animal excreta and some fertilisers (urea, diammonium phosphate). The ammonia is volatilised at rates that can vary extensively and be transported away by the wind. Some ammonia reacts to form atmospheric aerosols, which present a health hazard and contribute to the formation of acid rain. Another fraction gets re-deposited on soil surfaces, where it constitutes an indirect source of nitrous oxide, which is why ammonia emissions need to be accounted for in the national greenhouse gas inventory. That need prompted MAF (now MPI) to fund a project to investigate ammonia emissions from cattle excreta.

Two experiments were conducted to determine emission rates in situ, in undisturbed atmospheric flow conditions. In both experiments, excreta were deposited inside a circle of 16 m radius, on the surface of a previously mown paddock. Horizontally transported ammonia was collected with samplers (Figure 1) at five heights in the centre of the treated circle, and emission rates computed with a mass-budget method. Sampling concluded when, after several days, the collected ammonia amounts had dropped to the resolution limit of the analysis method.

In the first experiment, a regular pattern of 156 realistically sized cattle urine patches (1.5L urine each) was poured within the circle. That way, the amount of applied nitrogen was accurately known, and 25.7% of that was found to have volatilised as ammonia over 6 days. The timing of the emissions reflects a chain of three processes: equilibrium exchange between ammoniacal-nitrogen dissolved in the soil water and gaseous ammonia at the water-air interfaces (within the soil pores), diffusion of gaseous ammonia in the soil layer, and diffusion of gaseous ammonia in the atmospheric surface layer between ground and sampling height.

In the second experiment, 12 cattle were kept inside the circle for 3 days, and fed with known amounts of fresh grass. The amount

FIGURE 1 Side view of an ammonia sampler, affectionately called “space shuttle”. The sampler rotates itself into the wind (here blowing from right to left). Inside is an elaborate array of metal surfaces coated with oxalic acid that traps the ammonia.

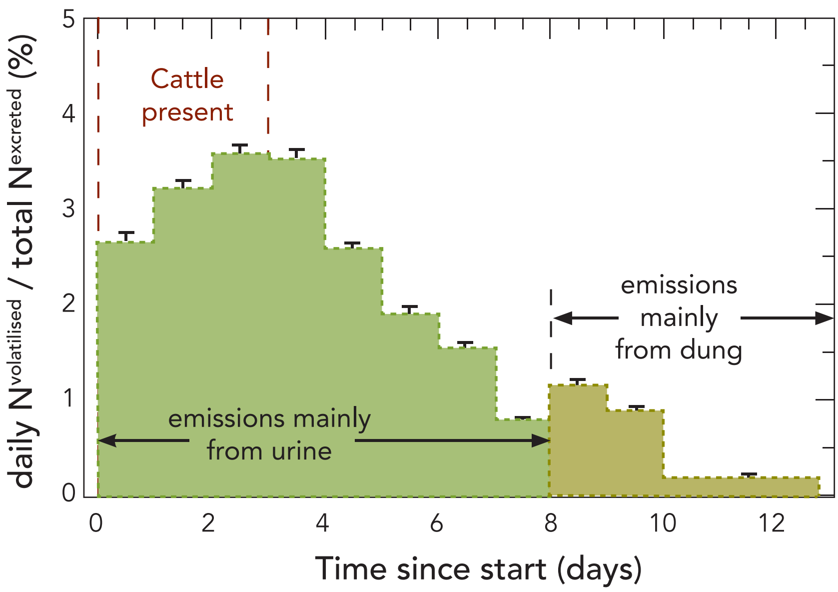

FIGURE 2 Day-to-day evolution of nitrogen loss fraction due to volatilisation, relative to the amount of nitrogen excreted by 12 cattle over the first 3 days. The vertical dashed line at 8 days marks when nitrogen loss rates cease to be dominated by volatilisation from urine, and emissions from dung probably begin to constitute the major fraction.

of nitrogen deposited with the urine and dung was estimated by analysing feed samples for nitrogen content and digestibility. Of the total nitrogen excreted, 78% was contained in urine. Over 13 days, 22.4% of the nitrogen excreted was volatilised. Most of the emissions occurred in the first 5 days, and a secondary maximum appeared on Day 9 (Figure 2). Measurements on a few urine patches and dung pats, created outside the circle, showed that the pH inside the dung pats rose more slowly and peaked later than in the urine patches, suggesting that the secondary emissions peak originated from dung. Separating urine and dung emissions accordingly led to the estimate that urine accounted for 88.6% of all ammonia emissions. 25.5% of the urine-nitrogen volatilised (as in the first experiment), and only 11.6% of the dung-nitrogen volatilised.

Both experiments were conducted in late summer, when soil temperature was 18 °C. In cooler conditions the emissions would have been slower and less in total. Taking this into account, the observed emission rates are compatible with an annually averaged emissions factor of 10%, for urine-nitrogen and dung-nitrogen combined, as presently used in New Zealand's inventory.

This research was conducted collaboratively with Drs Arezoo Taghizadeh-Toosi, Robert Sherlock, Jim Gibbs (all Lincoln University) and Frank Kelliher (AgResearch).

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Can we manipulate denitrification processes to reduce nitrous oxide and increase dinitrogen emissions?

Professor Surinder Saggar is leading the Landcare Research and New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) funded work on denitrification. Even though denitrification is the primary process of nitrous oxide production in pasture soils, there is still much more to understand about the controlling factors. Much denitrification research to date has focussed on reducing nitrate in waters rather than gaseous emissions into the atmosphere. However, with increasing concern about greenhouse gas emissions, scientific interest in the denitrification process is growing.

"In an ideal world, we could reduce the amount of nitrate in the system to zero, by using inhibitors or alternative technologies, and thus eliminate agricultural nitrous oxide emissions", says Surinder. "However, this is not currently possible and we need to acknowledge nitrate is present in the system and work out how to change it to the benign gas dinitrogen. Not much research has been conducted on what to do once the nitrate is formed in soils or even what is happening in the denitrification process". Certain microorganisms have the capacity to change nitrate into nitrous oxide, and some can change it to the environmentally friendly dinitrogen.

FIGURE 1 Cattle urine treatments being applied to field plots at Massey University Dairy Farm No.4, by Peter Berben (left) and Doug Drysdale (Royal Society-funded teacher trainee).

Difficulties in accurately measuring dinitrogen production under a nitrogen-rich atmosphere and identifying denitrifiers (and/or underlying enzymes) are key bottlenecks in the denitrification research. To address these bottlenecks, funding from Landcare Research is being used to develop a direct and simultaneous quantification procedure for nitrous oxide and dinitrogen measurements to improve understanding and estimation of gaseous losses of nitrogen.

NZAGRC is currently funding work on manipulation of soil and environmental conditions. This research has so far shown that New Zealand dairy-grazed pasture soils have wide variations of denitrification enzyme activity, denitrification rate, and nitrous oxide to dinitrogen ratio. The key soil factors influencing these (and thus the amount of nitrous oxide produced) include nitrate concentration, Olsen P, soil moisture, soil microorganism biomass, and soil carbon status.

The next steps of the research will focus on understanding how soil, climatic and/or microorganism parameters affect the functioning of microorganisms and associated enzymes, and how these can be manipulated. For example, nitrous oxide can be produced by several enzymes and microbial pathways but bacterial nitrous oxide-reductase is the only enzyme capable of reducing nitrous oxide to dinitrogen. Key enzymes identified in the denitrification process all have their own specific optimal working conditions. That is, some do their job most efficiently at high or low soil pH and soil water conditions, and others require the presence of other elements (e.g. copper) to work at all. Exploitation of these differences may provide potential routes for future nitrous oxide mitigation.

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FIGURE 2 Static chambers are installed for field measurements of nitrous oxide emissions from plots treated with and without cattle urine, by Peter Berben (left) and Thilak Palmada.

Conditions and trends of ecosystem services – an update

John Dymond, Anne-Gaelle Ausseil and Alexander Herzig have recently completed a tour of North Island regional councils where they presented results from their assessment of conditions and trends of ecosystem services.

"Ecosystem services for multiple outcomes" is a 4-year programme characterising and mapping ecosystems and providing suggestions for how these should be dealt with and services implemented at policy level.

Managing for multiple ecosystem services uses current information on the state of ecosystem services to assess potential and actual trade-off in the management of these services. These trade-offs are being further explored with the use of two catchment-scale case studies from the Manawatu and Canterbury.

Key findings of the research to-date are:

- Nitrate inputs to freshwater are increasing in Canterbury, West Coast, and Southland, and decreasing in Manawatu-Wanganui, Northland, Bay of Plenty, and Auckland. Elsewhere there is little change over the past 20 years (Figure 1).
- Agricultural greenhouse gases have increased in the last 20 years in Waikato, Canterbury, Southland, and Otago due to increase in animal numbers (Figure 2).
- There is a continued loss in indigenous vegetation: only 28% of original indigenous forest remains in New Zealand, 51 000 ha have been lost in the last 20 years; 43% of tussock grasslands remains, with 71 000 ha lost in the last 20 years; 10% of New Zealand's original wetlands remains, with proof of continued loss in the last ten years.
- 0.5% of high-class land has been urbanised in the last 20 years. 10% of high-class land is presently occupied by lifestyle blocks.
- Landscapes can be configured differently to optimise ecosystem services using the Land Use Management Support System (LUMASS) tool. LUMASS finds the optimal spatial configuration for a set of land uses, with a set of criteria. These criteria can, for example be "minimising nitrate leaching" maximising carbon sequestration", or a combination of these.

John Dymond says councils need to know the conditions and trends of ecosystem services because they are the policy agencies primarily responsible for ecosystem services. The results of this research are also useful to land planners, scientists and land managers. "Policy analysts and land planners will use the results to determine whether past policies need changing to protect or enhance ecosystem services. Managers of environmental projects can use the data and models developed to better assess the results of planned environmental work, such as soil conservation schemes."

The feedback from the regional councils was positive, with interest in accessing the maps to report on the state of ecosystem services in their region, and interest in the models to monitor progress for soil conservation programmes and planning purposes.

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ANNE-GAELLE AUSSEIL AND ALEX HERZIG

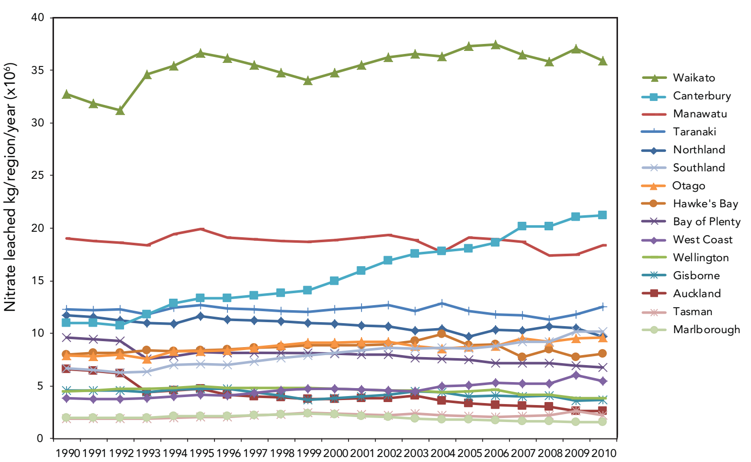

FIGURE 1 Trends in total nitrate leached per region 1990–2008.

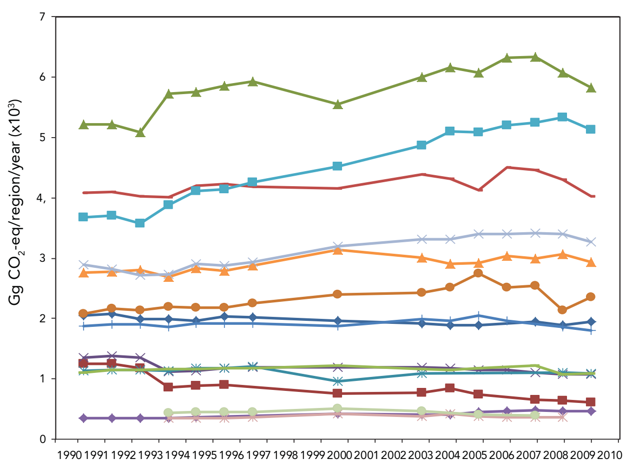

FIGURE 2 Trends in agricultural greenhouse gas emissions per region 1990–2008.

Water quality issues at the regional scale

Regional Councils are charged with managing the cumulative effects of land use on water quality. With the promulgation of the National Policy Statement for Fresh Water and the recent release of the second Land and Water Forum Report, more effective mechanisms for managing land use to meet water quality limits are urgently required. Landcare Research, through its collaborative relationship with Environment Canterbury, has helped develop this evidence base for the Canterbury region by comparing, integrating, and synthesising data and modelling across different soils, land uses, and scales (field, farm, aquifer, catchment, and regional).

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

In another study, commissioned by Environment Canterbury, the science sector was requested to run farm-scale models to provide estimates of nitrate leached below the root zone under a range of land uses for a range of Canterbury soils. We selected and characterised the soils, then compared and critiqued the modelled values, producing a consensus report of best available estimates of leaching values.

At the aquifer/catchment scale, and in collaboration with Lincoln Ventures Limited, we have developed a spatial model (AquiferSim) to understand potential land intensification options on water quality in aquifers and spring-fed streams. This model is specifically designed to explore the impact of different scenarios within minutes – rather than weeks, as with more complex models. Another design criterion was its capacity for use where there is limited geohydrological data (good information is only available for a few aquifers in New Zealand). AquiferSim was tested in the Central Canterbury Plains (with good data) and in the Hurunui where there is little data information. The Hurunui case study involved the development of methods to integrate with an existing catchment-scale model for surface water. This modelling work contributed to the Environment Canterbury's Land Use and Water Quality Project, a collaborative process with stakeholders that resulted in the Hurunui and Waiau River Regional Plan. We are now working with Environment Southland to apply AquiferSim to the mid Mataura basin.

At the regional scale we have developed new spatial models of contamination risk by bringing together Landcare Research's powerful new soil database S-map and relevant research on contaminant pathways. This helps landowners determine where mitigation land management practices are needed, and enables regional councils to apply more appropriate consenting rules for effluent disposal and septic tank discharge fields.

Developing and evaluating policy: Working with Environment Canterbury we developed a new method for allocating a catchment-scale nutrient limit between farms. This method focuses the requirement for more intensive mitigation practices on those land areas where there is a nitrate contamination problem, i.e. intensive land use on leaky soils in catchments known to have poor water quality.

We have also worked with Environment Canterbury to produce regional maps of nitrate concentration in the shallow ground water in Canterbury (using farm-scale modelled nitrate values). These maps were used in the Canterbury Water Management Strategy Strategic Framework document to highlight the impact of intensification due to increased irrigation. More recently we have used an updated regional nitrate-leaching map to provide statistics on the impact of nitrate thresholds being considered for the draft Canterbury Land and Water Regional Plan.

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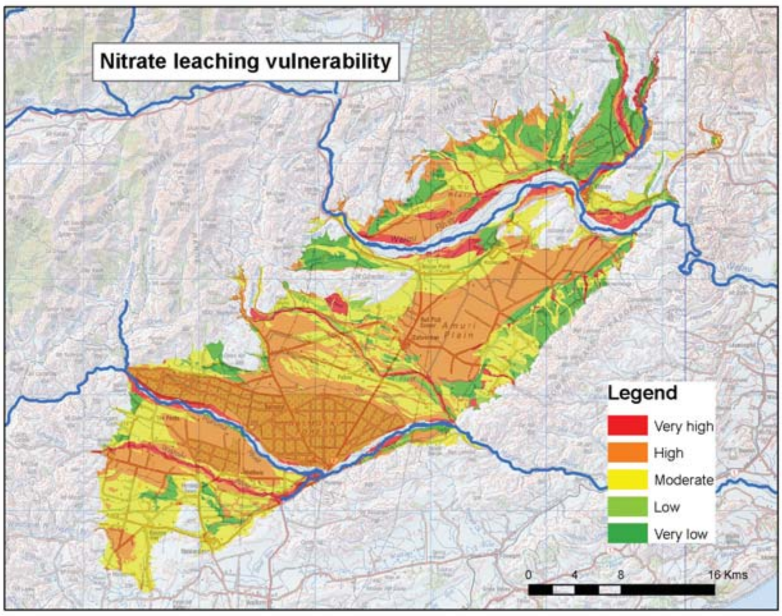

FIGURE 1 Nitrate leaching vulnerability for part of the Canterbury region.

Upscaling greenhouse gas emissions and carbon sequestration

Our research priority area combines observed data and process-based insights and databases with advanced models to improve estimates of greenhouse gas emissions scaled from small plots to catchments and then to New Zealand.

We are working on two main process-based models to upscale greenhouse gas emissions and carbon:

First, we have used a process-based soil greenhouse gas flux model (NZ-DNDC) to generate look-up tables for potential nitrous oxide emission factors using 20 years of climate data over a range of soil types, climatic conditions, and farm management practices (Figure 1). The emission factors are the average emission rates of nitrous oxide relative to the amount of nitrogen inputs. By multiplying the emission factors by the inputs in nitrogen (from animals and fertilisers), we can estimate the spatial pattern of nitrous oxide emissions and chart the impact of land-use change on emissions from catchment to national scales. This approach incorporates variability associated with soil and climate and will improve the estimation of emissions nationally.

Second, we are also developing and applying a carbon and nutrient-cycling model, CenW, to model the exchange of carbon of different vegetation types under different soil and environmental factors (Figure 2). We used CenW in a recent contract for the Ministry for Primary Industries to generate productivity surfaces of *Pinus radiata* and kanuka/manuka under both current climatic conditions and various climate-change scenarios. Growth of both stand types is likely to benefit from moderate climate warming, especially in the South Island. Factoring in increases in carbon dioxide concentration is likely to result in enhanced growth across New Zealand.

Our aim is to combine and further develop these internationally recognised models to provide a comprehensive tool to predict current and future carbon storage and greenhouse gas emission trends.

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DONNA GILTRAP, MIKO KIRSCHBAUM AND KALISH THAKUR

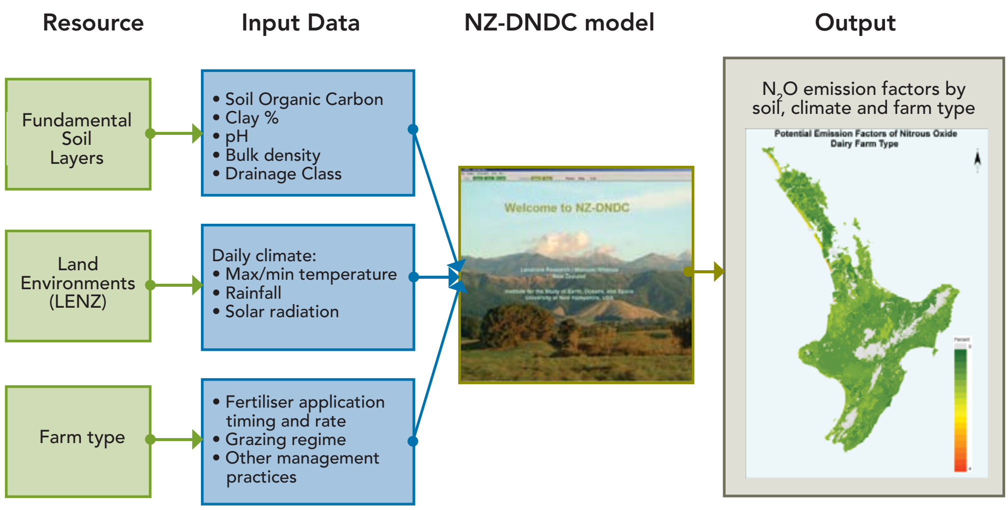

FIGURE 1 Upscaling NZ-DNDC to generate nitrous oxide (N_20) emission factor maps.

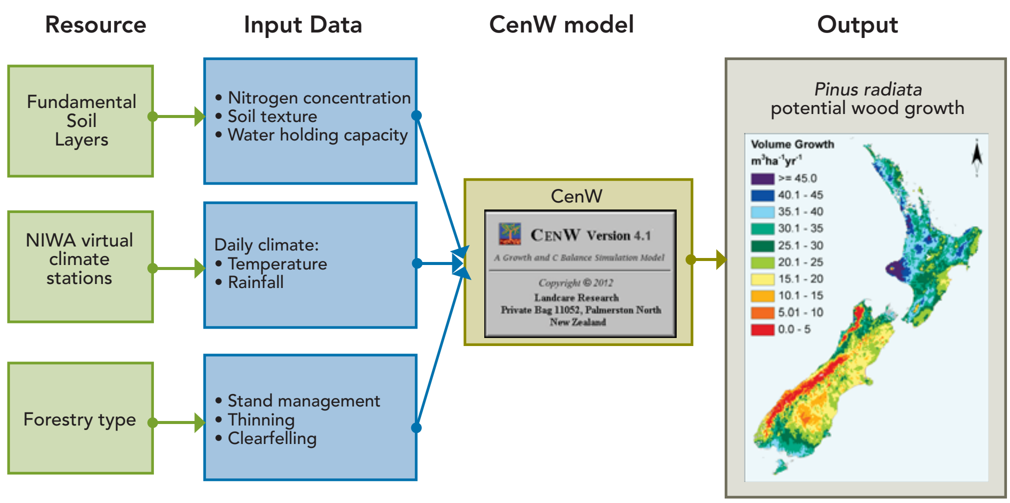

FIGURE 2 Upscaling CenW to generate *Pinus radiata* productivity maps.

Does clay stabilise organic matter in New Zealand soils?

Soil organic matter is stabilised in soils, and up to half of it can be 1000 years old or more. Scientists think that clay stabilises soil organic matter by various chemical (e.g. as inert molecules) and physical (e.g. in very small pores) processes. Clays have reactive surfaces and their surface area can be measured from water adsorption measurements. We have looked for a relationship between soil organic matter (carbon %) and clay for soils held in the National Soils Database. There is almost no relationship for topsoils under pasture (Figure 1). However, when we plot carbon % against soil surface area there is a good relationship (R2=0.61) (Figure 2). Soils with the greatest surface area are the Allophanic soils, derived from volcanic materials, and these soils are often not considered in overseas literature.

As many factors affect soil organic matter stabilisation, the relationship in Figure 2 is not perfect. Landcare Research is studying these other factors, which in addition to those mentioned above include stabilisation by iron oxides and aluminium (Figure 3), and by different types of clay minerals. Landcare Research is developing a thermal decomposition index to characterise soil organic matter stability in soils of varying mineralogies.

Fesh soil organic matter (e.g. from fresh roots and litter) makes up the labile pool, and with time becomes partially decomposed and partially stabilised in soil. A portion of the soil organic matter tends to be stabilised for 10–20 years, and we call this the "decadal pool". This pool typically accounts for over half the organic matter in soils. These pools have recently been measured (using 14C from nuclear bomb testing) in work in association with GNS. The residence time of organic matter in the decadal pool is 17 years for an Allophanic soil compared with 9 years for a non-allophanic soil.

Other work on soil organic matter stabilisation is currently being funded by the Sustainable Land Management and Climate Change (SLMACC) initiative of MPI (Ministry for Primary Industries) and from the New Zealand Agricultural Greenhouse Gas Research Centre, in conjunction with Plant & Food, AgResearch, and Massey University (biochar). Soil surface area has been used to help assess the maximum amount of soil organic matter stored in New Zealand soils in these projects.

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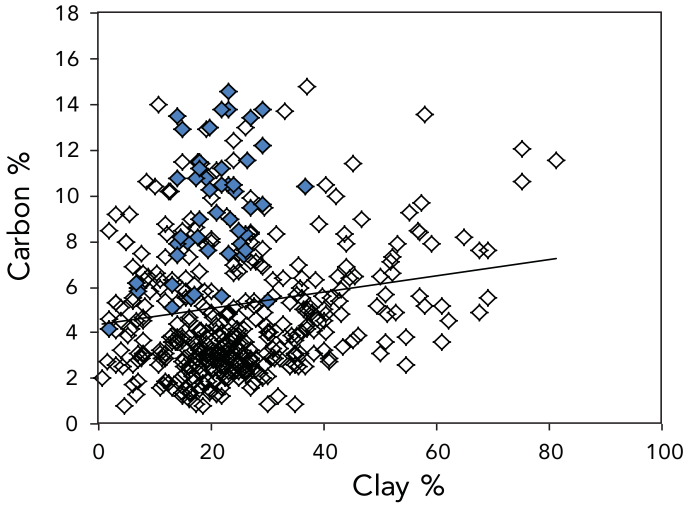

FIGURE 1 Soil carbon % plotted against clay %, for topsoils under pasture. Allophanic soils have solid diamonds.

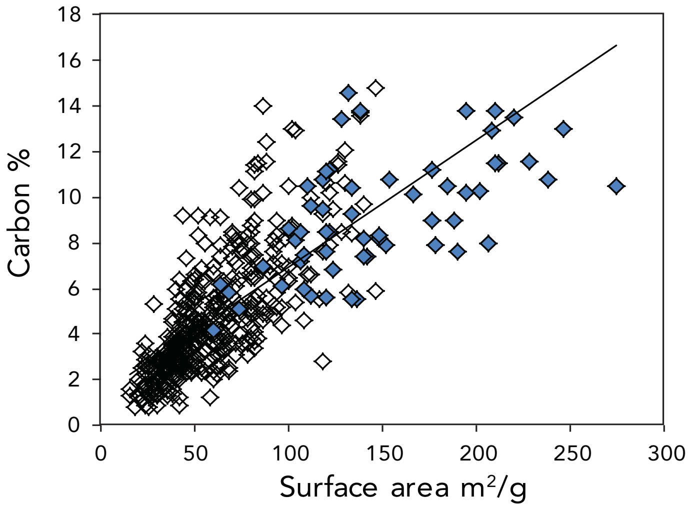

FIGURE 2 Soil carbon % plotted against surface area of soil, measured from water adsorption, for topsoils under pasture. Allophanic soils have solid diamonds.

FIGURE 3 Carbon accumulation (16.8%) as aluminium-humus in a black layer (1 m thick) near Mt Aso, Japan.

A national update on land cover change

The third version of the Land Cover Database (LCDB) – the authoritative record of changes in land cover in New Zealand was publically released at the end of June on our download site **http://lris.scinfo.org.nz.** The database classifies all land cover under 33 different classes at three nominal summer periods (1996/97, 2001/02 and 2007/08).

Producing LCDB v3.0 was the major achievement from the first year of our 4-year contract with the Science and Innovation Group within the Ministry of Business, Innovation and Employment (MBIE) to generate new editions and to conduct the necessary research and development to improve mapping quality, efficiency, and accessibility. Building on the first two LCDB versions, produced in 2000 and 2004, the latest database makes use of improvements in the resolution of satellite imagery, as well as Landcare Research's advances in image processing technology to provide an accurate record of New Zealand's land cover.

Version 3.0 contains a third time-step based on about 160 satellite images captured over the 2007/8 summer. In addition to the extra time-step, significant improvements have been made to its classification accuracy, its line work quality, and its consistency with other New Zealand map datasets.

Around 64 000 polygons were manually modified in this revision, with about 36% of these being real change between 2001/02 and 2007/08 and the remainder being corrections on previous mapping (at 1996/97 & 2001/02). A further 200 000+ polygons or polygon parts, out of a total of 450 000, were modified by semi-automated adjustments (excluding smoothing artefacts).

We've had great support from users of the database. Regional councils, territorial authorities, Department of Conservation, Ministry for Primary Industries, and the Fire Service were given the opportunity to review the draft LCDB v3.0 mapping of their interest area and to provide feedback on general problems as well as specific errors they had identified. At least 16 organisations provided feedback on their areas; in some cases this feedback was comprehensive. Around 3000 of the 64 000 manually modified polygons were the result of checking or other information provided by these collaborating agencies.

Before updating the maps, an automated process was applied to smooth step artefacts found in the previous version. These artefacts originated from pixel level classification and their removal results in a much cleaner and more appealing map product as shown in Figure 1.

The LCDB technical advisory group decided to adopt the Topo50 coastline to make LCDB easier to integrate with other New Zealand datasets. The process is illustrated in Figure 2, where most classes are clipped or extended to the Topo50 coastline. Three classes – "Mangroves", "Herbaceous Saline Vegetation", and "Estuarine Open Water" – are allowed to exist outside the coastline, so an "onshore" flag is used to indicate polygons inside the Topo50 coastline.

Currently, we are assessing the accuracy of the new LCDB product and should have initial results by September. We will then go back to users for their feedback on the strengths and weaknesses of LCDB v3.0 and also to survey other datasets held that might be useful to improve future LCDB versions.

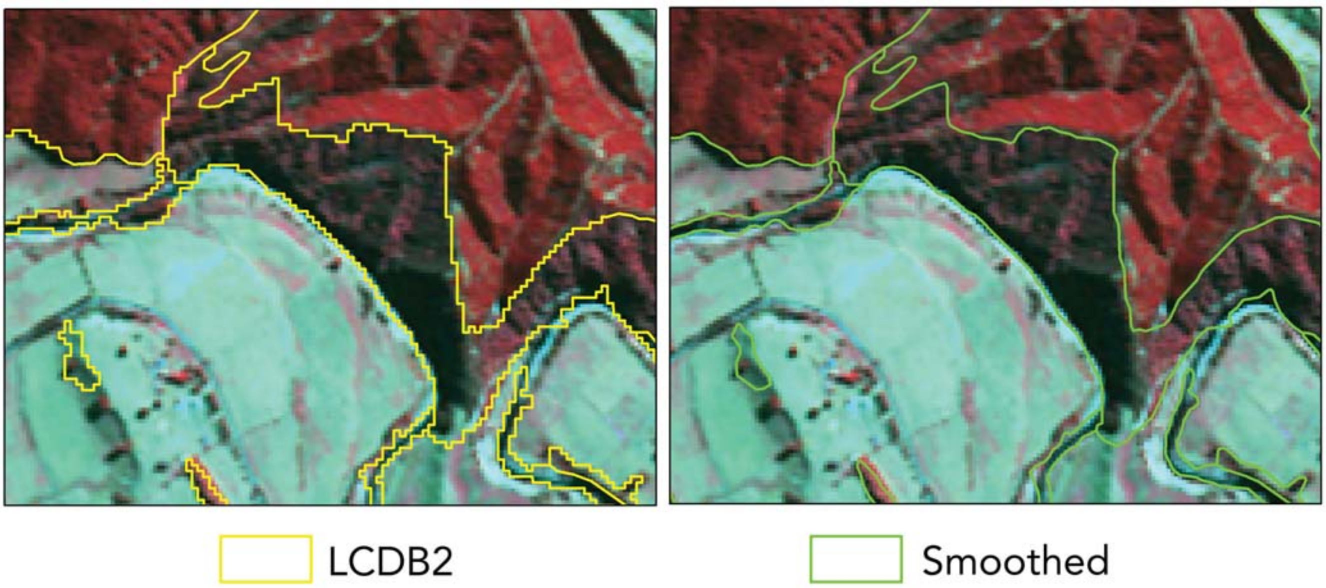

FIGURE 1 Original stepped boundaries in red, smoothed boundaries in yellow.

Behind all this we have an exciting research programme aimed at improving the efficiency and accuracy of mapping from remotely sensed imagery. A priority here is to integrate automated segmentation methods to reduce the amount of hand-digitisation required. We are also developing smart vector editing techniques to integrate new polygons with existing maps without generating slivers, gaps or breaking topology.

See the LCDB website at **www.lcdb.scinfo.org.nz** for more information on the programme.

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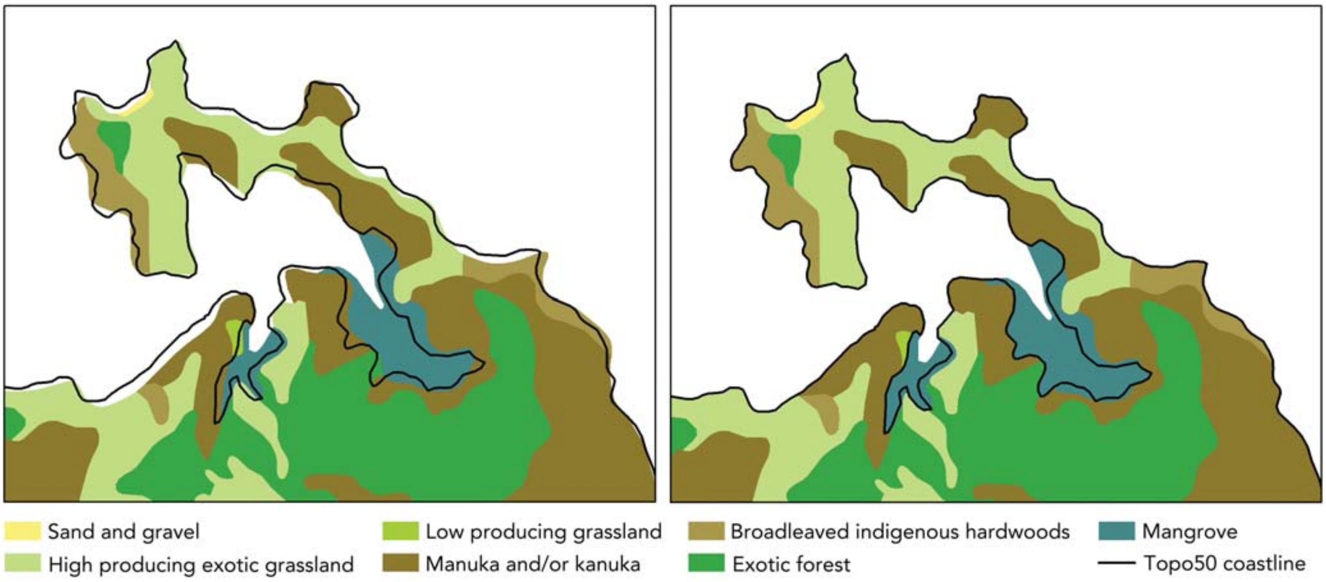

FIGURE 2 The original LCDB "coastline" was simply interpreted from imagery. As seen on the left, it often deviated from the Topo50 coastline (bold line). On the right, polygons have been made consistant with the Topo50 coastline.

SedNetNZ: a new model to predict land management effects on erosion and sediment yield

Land managers are increasingly turning to spatial modelling to predict the effects of land use on environmental outcomes. Effective land-use modelling requires tools that can target critical source areas for sediment generation and subsequently predict the impacts of future upstream land management scenarios on downstream water quality and quantity. There is also a need to evaluate contemporary loads in relation to the natural or background loads.

Existing erosion and sediment yield models can contain no information on the contribution from different erosion processes (e.g. Suspended Sediment Yield Estimator, NZeem®), do not simulate the full range of erosion processes present (e.g. GLEAMS), or require vast amounts of data and processing power to run them (e.g. SHETRAN). There is clear need for a model that combines realistic data requirements with better erosion process representation, explicit linkages between hillslopes and channels, and simulation of catchment-scale connectivity, so that we will be better able to simulate the effects of changes in land management on upstream sediment loading and downstream responses.

SedNetNZ is based on the Australian SedNet model, a spatially distributed, time-averaged model that routes sediment through the river network using a sediment budgeting approach. It is based on a relatively simple physical representation of hillslope and channel processes that contribute to each stream link in a river network (Figure 1), accounting for losses in water bodies (reservoirs, lakes), and deposition on floodplains and in the channel. SedNetNZ will simulate the contribution of sheet and rill erosion, landslides, earthflows, gullies, and bank erosion, processes that collectively account for the majority of erosion and sediment generation in the New Zealand landscape. It also accounts for floodplain deposition (Figure 2).

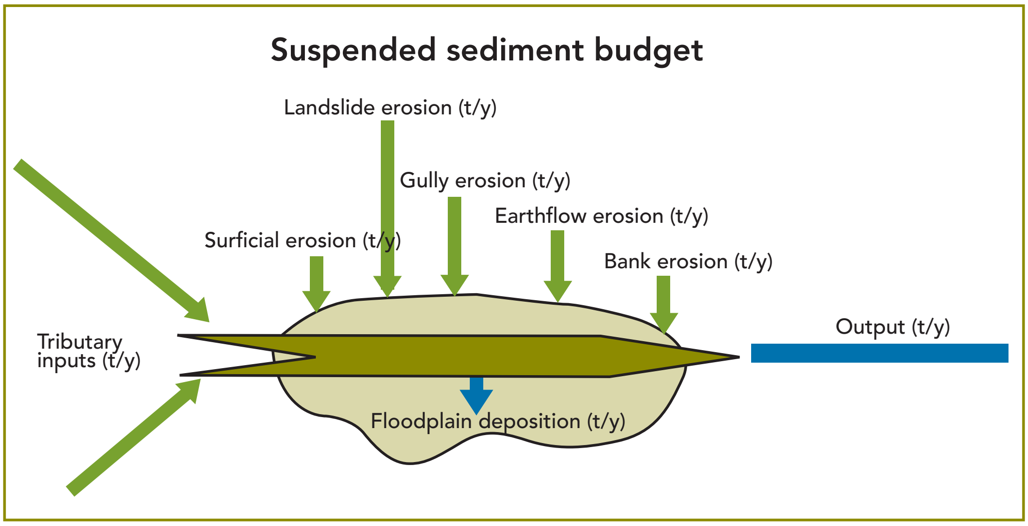

FIGURE 1 Stream link and river network in part of the Manawatu catchment.

The Manawatu River is being used as a case study for model development because it has major erosion and sedimentation issues, considerable existing erosion and sediment yield data, and a high likelihood of major land management change that can be used to test the model. To parameterise the model considerable effort was needed to characterise erosion processes within the Manawatu catchment, including mapping of historical landslides and determining the relationships between landsliding probability and slope angle, as well as mapping earthflows and determining their contribution to the channel network.

As part of the background work to ensure the model accurately simulates river sediment loads, we have analysed suspended sediment data collected by Horizons Regional Council at eight sites within the Manawatu catchment over the last ten years. Measured suspended sediment yields range from 960 t/km^2/yr in the Pohangina River to 440 t/km^2/yr in the Tiraumea River, considerably less than yields predicted by existing models.

When fully developed, the SedNetNZ model will be a major step forward in providing land managers with tools to simulate erosion processes realistically and to determine the linkages between hillslope and channel processes.

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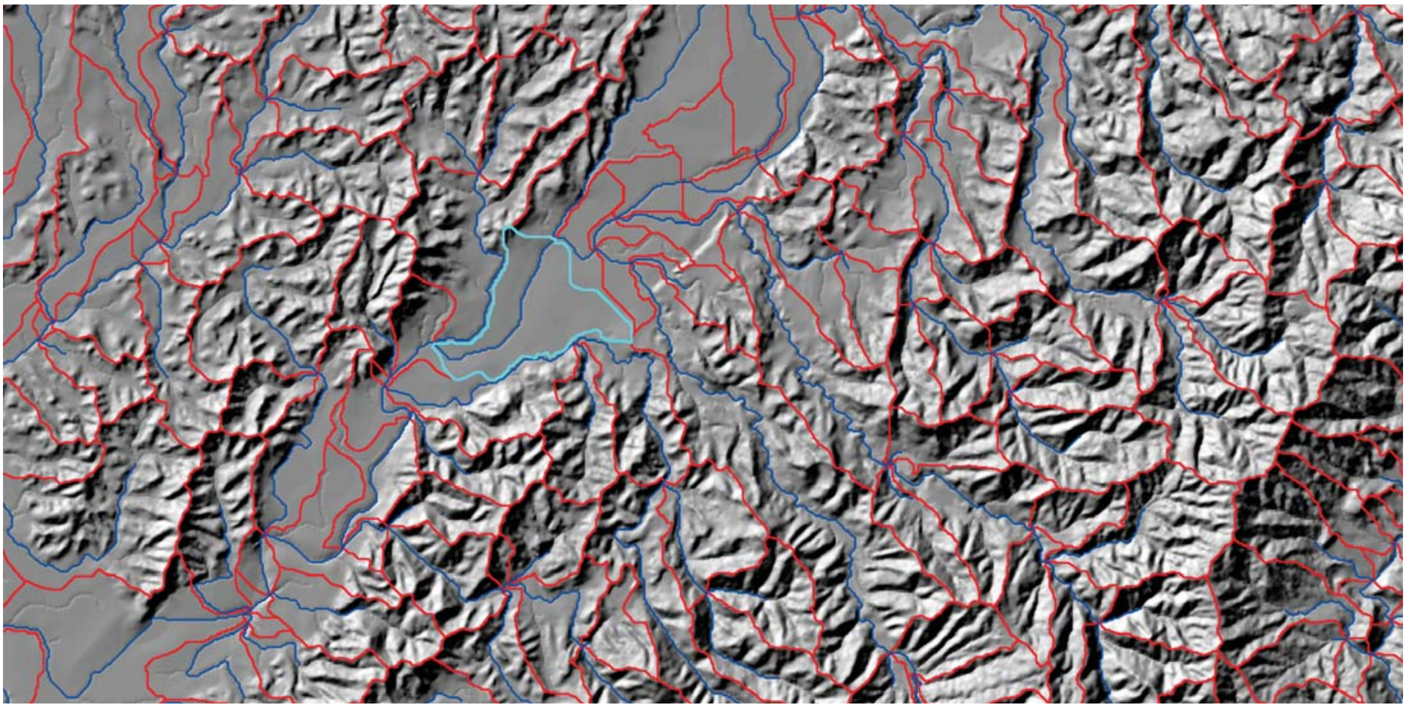

FIGURE 2 Conceptual structure of SedNetNZ for each stream link.

To apply or not to apply biosolids to land – what are the potential impacts from organic contaminants?

Municipal biosolids are rich in nutrients and can be applied to land to fertilise plants and improve the quality of soil. Approximately 320 000 wet tonnes of biosolids are currently produced by municipal wastewater treatment plants across New Zealand. Of this, an estimated 40% is applied to land, with the remainder disposed of as land-fill or held in long-term on-site storage. Concern about the potential negative effect of biosolid application arising from the presence of pharmaceuticals and other organic contaminants in the biosolids is a barrier to facilitating further beneficial reuse. However, there is also limited knowledge about these contaminants, including their potential environmental effect, in New Zealand.

As part of the Biowaste Research Programme led by ESR with collaborators from Landcare Research, Cawthron Institute, Scion, and Plant and Food, we are investigating the biological impacts of biosolids and biosolid contaminants in the environment using cell-based or *in vitro* tests, and whole organism tests.

The different types of environmental impacts we are assessing using our *in vitro* tests include:

- Stimulation of male (androgenic) or female (estrogenic) hormone activity
- Inhibition of male or female hormone activity by anti-androgen or anti-estrogens
- Stimulation of a detoxification enzyme (CYP1A1)
- Mutagenic activity

Our whole organism tests focus on soil organisms, in particular the earthworm, *Eisenia fetida* (Figure 1) and the springtail, *Folsimia candida*, since land application is a key beneficial use of biosolids. We assess the reproductive endpoints including cocoon and juvenile production in these test species to assess the long-term (chronic) effect of contaminants.

FIGURE 1 *Eisenia fetida* (red compost worm).

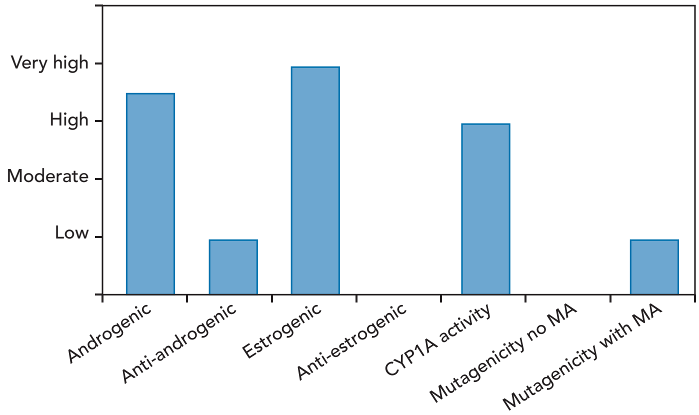

FIGURE 2 Relative activity of biosolid extracts (Androgenic – male hormone activity; Estrogenic – female hormone activity; CYP1A – detoxification enzyme; MA – metabolic activation).

Our *in vitro* tests are used to examine the biological activity or toxicity associated with the chemical mixtures found in biosolids collected from municipal wastewater treatment plants across New Zealand. The relative biological activity of organic extracts as measured by the different *in vitro* tests is shown in Figure 2.

Both our *in vitro* tests and earthworms tests have been used to assess the toxicity of selected contaminants of concern found in biosolids. These are triclosan, an anti-microbial compound found in soaps, toothpaste, deodorants, and other personal care products, the plasticiser, bisphenol-A, and the pharmaceutical, carbamazepine, used for the treatment of epilepsy and bipolar disorder.

Testing on earthworms showed that bisphenol A had the greatest effect and carbamazepine the least effect on earthworm cocoon and juvenile production. Triclosan caused a decrease in hatching success and number of juveniles per cocoon, while bisphenol-A and carbamazepine had no effect.

Understanding the environmental effects of biosolids and associated contaminants, particularly "new" organic contaminants, will enable the risks and benefits of land application of biosolids to be better assessed. This will inform guidelines for beneficial reuse, including recommended application rates and timing for biosolid application to land.

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Better management of environmental data

At a time when we require comprehensive information about environmental state and trend, we also seek better return on investment in data collection through reuse and secondary use of existing data. Landcare Research also has to meet contractual obligations and fulfil mandates from Government to improve access to data, as well as international obligations to provide open access to science data. So what is Landcare Research doing about this?

First, we recently conducted an audit of the soil and land data assets that Landcare Research holds. The focus was wide, including the physical collections, e.g. the National Soil Archive (Figure 1), non-digital and digital data, held by individuals and within the institutional data management framework. The audit identified areas of concern: much of these data are poorly managed and some are at risk of being lost; some 75% of the institutionally managed data have no on-going funding; 19% have on-going funding for maintenance only, e.g. the New Zealand Land Resource Inventory (NZLRI) and the National Soil Database (NSD); and much data is not fit for today's requirements but could be with some investment. The data held by individuals, however, seem to have untapped value, being more current, of better quality and at larger scales – yet are essentially unknown or only known by a few people.

Second, a short Envirolink funded project has assessed the current status of the National Soil Database (NSD) and scoped a roadmap for its future. The review canvassed future requirements for the NSD from users in five regional and unitary councils, data managers and domain experts. The result is a new vision for the NSD that seeks to improve data management and data access, better indicate varying data quality, and integrate related data to add value to the NSD as a whole.

The final activity, starting very shortly, will seek stakeholder's views on how the NZLRI might be improved. This "nationally significant database" is often referred to as a "nationally consistent" view of the natural resources of New Zealand. It has been widely used in land-use planning for at least

FIGURE 1 New Zealand National Soil Archive, Palmerston North

35 years, and is frequently quoted in central, territorial, and local government policies, and in resource consent hearings. However, the NZLRI has a number of shortcomings that increasingly raise questions about its 'fitness for purpose'. LCR staff have already begun to develop a set of recommendations to address these shortcomings but we will also seek feedback from key users on their needs and the proposed improvements. As for the NSD, since these improvements will require significant work, new funding will be needed.

So we are taking the first steps towards improvement. Our goal is to ensure the continuing availability of authoritative soils and land data assets of long-term value to support research, for use by our stakeholders, and for wider exploitation for the public good. However, there is increased user demand for customised data and information products. Creation of these products is one of the goals of the new NLRC. Staff from the NLRC will work with stakeholders to determine their needs and the potential to create new, more usable, and more focused products and services using data held by Landcare Research, other CRIs, and agencies.

David Medyckyj-Scott - Research Priority Area Leader - Data stewardship & Information Services within Landcare's Characterising Land Resources Portfolio & Technical Director, National Land Resource Centre

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