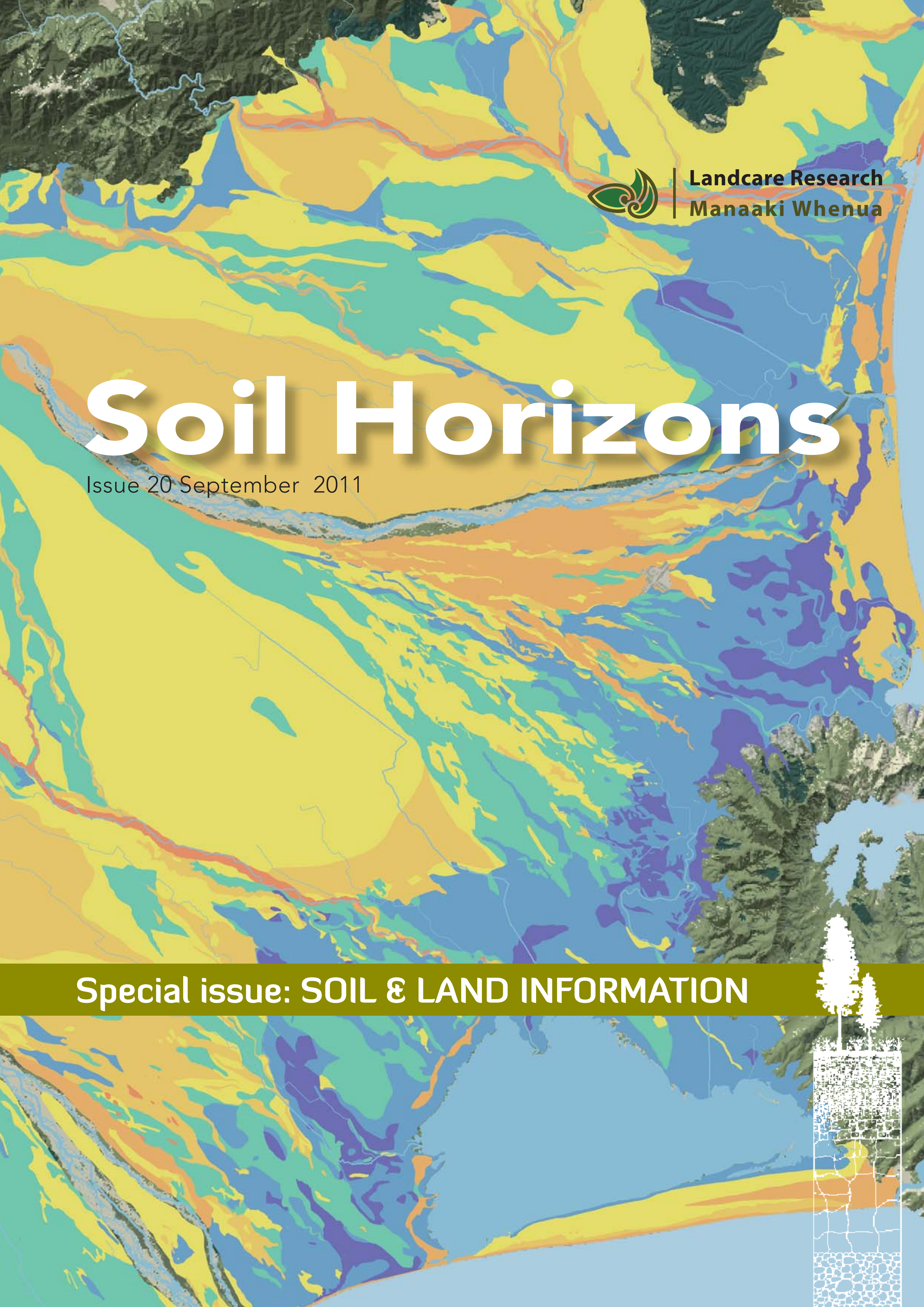

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Manaaki Whenua

Soil Horizons

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Front cover
SOIL MOISTURE LAYERS MAP GENERATED USING S-MAP ONLINE

In this Issue

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Editorial

In this 20th issue of Soil Horizons we highlight our latest advances in the collection, use and sharing of nationally important soil and land resource data. This is very timely because this month the FAO launches the Global Soil Partnership (GSP) for Food Security and Climate Change Adaptation and Mitigation: www.fao.org/ag/agl/docs/GSP_background_paper.pdf.

In this press release the FAO acknowledges the critical role of the soil resource in assuring global food security, and increased public awareness that soils play a fundamental role in climate change adaptation and mitigation. The FAO is calling for harmonisation of standards in soil research, strengthening of soil data and information, and a promotion both of targeted soil research and development and of sustainable management of soil resources and soil protection. They also encourage investment and technical cooperation to meet these goals.

We think the articles in this issue address these FAO goals – they provide a science research update and remind the reader that although we are making great progress there is still much work to be done. Alison Collins (Acting GM, Environment and Society) sets the scene with her article "Land Resource Information: A strategic roadmap for the future".

THE EDITORS
September 2011

Land Resource Information: A strategic roadmap for the future

Landcare Research, like all the Crown Research Institutes, has agreed a *Statement of Core Purpose* in partnership with stakeholders and shareholders, mapping out where and how our science can deliver national benefit. *'Achieve the sustainable use of land resources and their ecosystem services across catchments and sectors'* is one of Landcare Research's four national outcomes.

Looking back, most of our research in the soil and land space has undoubtedly focused on this aspiration, but we asked ourselves whether there was a more strategic approach we could take to deliver this outcome? We asked this question in a series of science and stakeholder workshops, as well as an online conversation about land resources. Better coordination and use of land resource research and data emerged as clear priorities.

Our Board of Directors recognised the potential benefits of greater coordination when presented with our findings, agreeing to invest in a strategic initiative to scope, plan and implement a **National Land Resource Centre**. Our vision is a Centre that can develop and maintain a significant data repository from a variety of sources (basic research from Landcare Research and other science providers; nationally significant databases and collections; major contracts; and government and industry stakeholders). Coordinating these data sets into robust and authoritative sources of information (in both electronic and hard copy) and using informatics innovations to provide easy access across a range of scales will be among the key improvements required.

In this edition of Soil Horizons we take you on a journey through our world of land resource data[1] and information[2], highlighting some of the challenges, opportunities, and advancements that will be addressed through a **National Land Resource Centre**.

We provide updates on improvements in the accessibility of data resources – whether it is a case of greater consistency in the way we refer to or classify our soils (*New Zealand Soil Classification updated and extended*) through to 'easy on the eye' portals and interfaces (*S-map Online: an interactive mapping and query application for New Zealand soils data* and *Supplying land and soils data over the web – the LRIS portal*) and interpretation of the data for end-users (*Ecosystem Services for Multiple Outcomes*). The usefulness of these portals, of course, is only limited by the quality and coverage of the underpinning data – which, as James Barringer et al. suggest, will be an ongoing challenge as we try to find ways to increase the coverage of S-map.

We provide examples of how data can be collected more quickly, effectively or cheaply using smart technologies (*Making better use of LiDAR in soil and landscape modelling* and *Tracking the depth to water table in the Manawatu Sand Country*). We highlight the importance of being part of global initiatives to harmonsie and optimise research, data, and information methods (*GlobalSoilMap.net*). We also present articles on some of the successful attempts to get the flow of research knowledge into improving the reliability, coverage and robustness of significant data sets (*Effect of erosion on soil carbon stocks*, *Detecting changes in soil carbon and nitrogen under pastoral land use in New Zealand* and *New Zealand Land Cover Database*); reflecting on the importance of revisiting, re-sampling and repopulating databases to extend their reliability and use to understand states and trends.

Finally two projects show that once data collection or data management methods have been established there are many ways in which they can be used to achieve impact. In this case we also review some interesting off-shore applications of land resource information (*Protecting coral reefs in the Pacific and Mapping Antarctic soils*).

The year ahead provides an opportunity to build on the many positive initiatives we review here. Through our core funding contracts and in partnership with our stakeholders we will move to a more strategic, coordinated and deliberate approach to assembling an information base for New Zealand land resources. Available to a wide range of organisations this information will help report on state of the environment, plan development within environmental limits, and ultimately, match land use to the capacity of land resources.

We'd like to thank you for your ongoing support of this research area and ask you to continue to assist as we build a roadmap of priorities for our **National Land Resource Centre**.

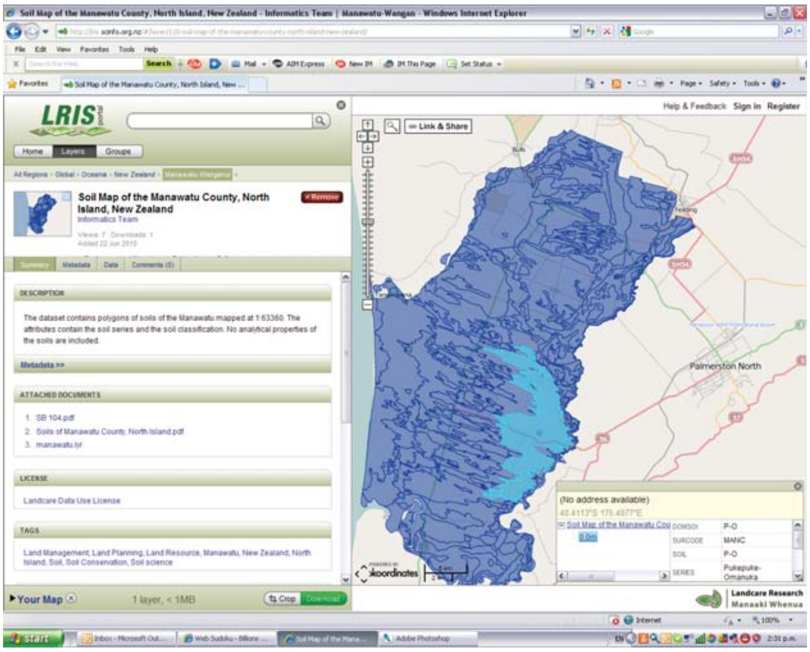
ALISON COLLINS

Acting General Manager, Environment and Society

1 With 'data' as qualitative or quantitative attributes of a variable or set of variables

2 With 'information' as data processed to be useful; providing answers to "who", "what", "where", and "when" questions

Supplying land and soils data over the web – the LRIS portal



Access to the national Land Resource Inventory (LRI) has been transformed through the use of Internet and 'Google Earth' style technologies. The LRIS Portal (http://lris.scinfo.org.nz) is an evolving, easy to use, online service that provides access to Landcare Research's geospatial data. Since publically launching in August 2010, this new data supply service has generated a wealth of interest from users, and over 1700 download requests have been fulfilled. The LRIS Portal is the first of a new series of web applications and services that Landcare Research is creating and rolling out over the next few years.

The LRIS Portal

Individuals working in regional and central government, industry, research, and education now have quick and easy access to environment data held by Landcare Research. These geospatial datasets, many of which are considered of national significance, can be used for creating maps, analysis, modelling, and generally for finding out about New Zealand's environments and land resources.

More than 80 of Landcare Research's land and soils datasets are available through the LRIS Portal. The data include records from the New Zealand Land Resource Inventory (NZLRI), data underpinning the Land Environments NZ (LENZ) data set, Fundamental Soils Layers (FSL), regional soil databases, and digital elevation models. These data can be used in a diverse range of applications, for example, catchment and resource management, national monitoring of carbon sources and sinks, and studies of climate change.

Using software provided by Koordinates Limited (http://koordinates.com), the service provides professional geospatial data users with easy and quick access to data. Designed to make the data usable, as well as accessible, each data layer comes with comprehensive metadata ('data about data'), supporting documents, and easy to understand data use licenses. Downloading data requires no special software, although GIS software or similar software is required for subsequent use of the data. Users can select from a variety of data formats and, using a map-based interface, sub-set the geographic extent of the data so they download data only for the area of interest.

Use of the LRIS Portal

The portal website has been extremely popular. Some 9500 individuals have visited the site since launch (95 000 page views) and many third party web sites provide a link to the Portal.

In 2009 Landcare Research supplied less than 50 LRIS datasets to users. Almost one year after launch of the LRIS Portal over 1700 download requests have been fulfilled. The most frequently downloaded data are: North and South Islands DEMs, FSL Soil Classification, NZLRI Vegetation, NZLRI Soil, and NZLRI Land Use Capability.

Impact

Feedback from a recent user survey found that the portal has radically improved the accessibility of LRIS data, saving time and money for users. The survey also found that making data available through the portal had resulted in a general increase in the use of environmental data as well as new information creation by merging LRIS data with other data.

The future

The portal itself represents the first phase of the development of Landcare Research's spatial data infrastructure. The next step is to make the LRI and soils data more directly usable for the non-geospatial professional. To this end a series of web mapping applications have been designed and built, using open source software, and these are being rolled out during 2011. The first of these is S-map Online, which is described in another article in this issue.

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S-map Online: an interactive mapping and query application for New Zealand soils data

S-map is a new digital soil spatial information system for New Zealand created as part of the government-funded SpInfo (Spatial Information) programme run by Landcare Research. S-map is designed to provide consistent and comprehensive national soil data layers to support applications at local and regional to national scales. It builds on previous soil mapping by filling gaps with new mapping and upgrading the associated soil property information to meet a new national standard. In time S-map will have national coverage and contain predominantly new digital data at a scale that resolves soil variation on hill slopes (nominally 1:50 000 scale). The rate of progress will depend on funding.

S-map Online

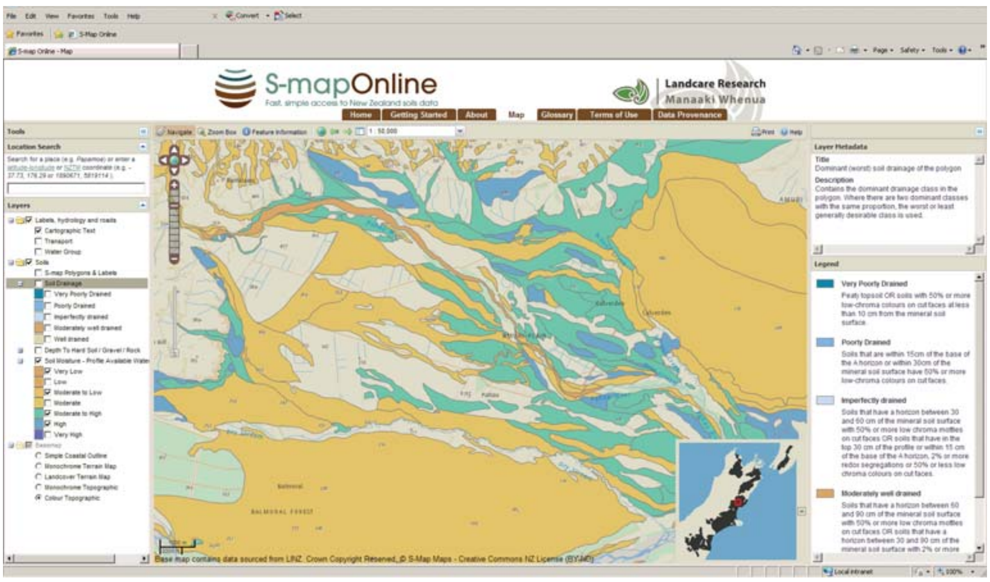
Although S-map coverage is not yet complete, there is sufficient cover that the Informatics team at Landcare Research has developed S-map Online (http://smap.landcareresearch.co.nz), a web browser service to provide easy access to information on the soils likely to be found at a location of interest (in those areas with available S-map data).

The new S-map Online service has adopted the user-friendly and now familiar "Google Earth" style navigation to make it easy to search, view, and query the S-map data. Using S-map online you can:

- explore interactive soil maps of soil properties such as soil drainage and available water
- learn about the soil in your backyard or paddock
- view detailed information about a soil class or attribute
- create custom PDF soil maps for printing
- for specific locations, download soil factsheets that provide more detailed knowledge of soil properties and information relevant to a variety of potential uses.

Access to the factsheet generator by searching on the regional soil name is still available.

The S-map Online web service has excellent, high-quality base maps, including maps based on LINZ topographic data. These allow you not only to locate an area of interest with a high degree of accuracy but also to provide a geographic context for the soils data.



The Future

S-map is currently being extended in the following areas:

- Environment Waikato territorial area
- Environment Canterbury territorial area
- Soft-rock hill country in the central North Island
- Small windows in Northland, Gisborne, Hawke's Bay, Manawatu, Wairarapa, Golden Bay, West Coast

There are also plans to develop the S-map Online glossary and factsheets further into a more fully featured knowledge delivery system to explain soils terminology and soil properties so users can develop their soil knowledge and ultimately make better informed and more reliable land-use decisions.

Alongside S-map Online, the Informatics team is launching Our Environment (http://ourenvironment.scinfo.org.nz), which will replace the old Geospatial Data integration Portal and give more general browse, map view, and query access to a selection of Landcare Research's databases. Both S-map Online and Our Environment are built using a new geospatial-portal-software platform for visualising geospatial data and for querying attributes of datasets. Designed and written by the Informatics team and based on open standards and open source software (including PostGIS, MapServer, Geo Tools and Open Layers), the platform will be used to roll out other web applications with rich data visualisations capabilities over the next few years.

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DAVID MEDYCKYJ-SCOTT, ALLAN HEWITT & LINDA LILBURNE

New Zealand Soil Classification updated and extended

A number of new soils have been recognised in New Zealand and are published in a new edition of the Soil Classification in New Zealand (Hewitt 2010). The new soils are mainly new subgroups, for example, a weathered subgroup has been added to Pallic and Brown soils that have underlying strongly weathered gravels (this material will have significant effects on deep percolation) and a tephric subgroup is recognised in Sandy Recent Soils. The previous fourth level of the classification (Soilform; Clayden & Webb 1994) has been modified and replaced with two new categories – the fourth and fifth levels, called the family and sibling respectively (Webb & Lilburne 2011).

The family is the category below Subgroup, and is designed to identify the dominant lithological composition of soil profiles. Families are identified by soil material, type of rock, texture, and the permeability classes in 100-cm depth. Recognition (or identification) of families follows the soil classification principles summarised by Hewitt (2010), particularly the following:

- The grouping of soils into classes should be based on similarity of soil properties rather than presumed genesis
- Differentiae should be based on soil properties that can be reproducibly and precisely measured or observed
- Differentiae should allow field assignment of soils to classes.

Soil families are given a geographic name and are also identified with a 4- or 5-character abbreviated name. Geographic names, also used to name soil series, have been retained because the users of soils are familiar with this usage. The family name is suffixed with an italicised '*f*' to distinguish the family from the soil series. Soil families are more precisely and objectively defined than the old soil series.

The fifth category (sibling) is designated by a number and further refines the description of the physical attributes. The sibling-level criteria are soil depth, topsoil stoniness, soil texture-profile, natural soil drainage, and a unique sequence of up to six functional horizons. The functional horizon codes indicate stone content, texture, structure size, and consistence. One small change that may be of interest to pedologists is the refinement of the imperfectly drained class, where pedons with mottled horizons above 30 cm and gleyed horizons below 60 cm are now classified as imperfectly drained soils rather than poorly drained soils. These soils commonly occur in Pallic environments that have a slowly permeable horizon in the upper subsoil but are not poorly drained (very few people would artificially drain these soils).

Application of the soil family and sibling criteria subdivides a number of the former soil series and merges others. Figure 1 gives an example of this. However, the new classification now correlates the same soil with the same name, wherever it occurs, rather than having different names within different survey areas. This means some soil names have changed and some South Island names will now occur in the North Island, and vice versa. All the pedons in the National Soil Database have now been classified at the sibling level and each measured horizon has been classified in terms of the functional horizons. This greatly facilitates the grouping of similar soils or similar horizons and increases our ability to estimate a wide range of derived information for soils throughout New Zealand. See the factsheets on http://smap.landcareresearch.co.nz for examples of the derived information.

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TREVOR WEBB AND ALLAN HEWITT

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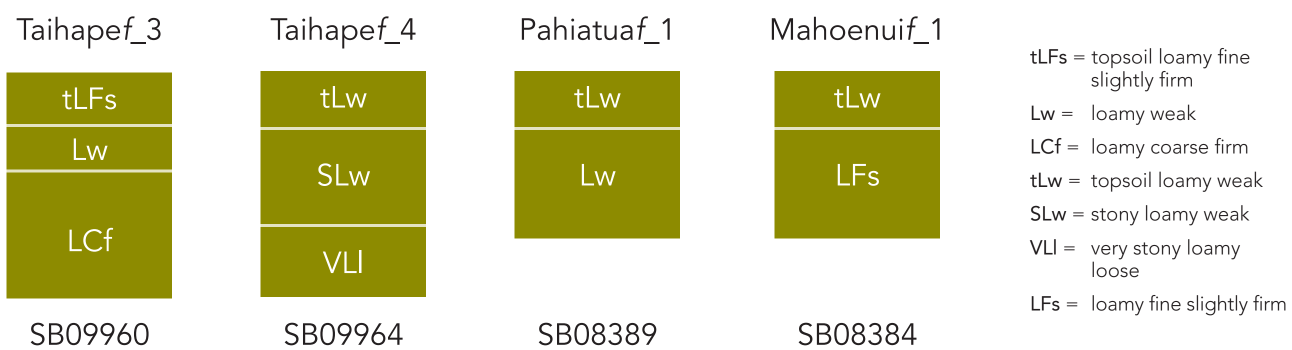

FIGURE 1 Illustration of the revised classification of four National Soil Database profiles from one soil series (Taihape) into three families. Each profile is labelled with its family name and sibling number. Each horizon is labelled with its functional horizon code. The Taihape*f* family is now more precisely defined as being Typic Orthic Gley, moderately deep on rock, silty, moderate over slow permeability. The shallower, better drained part of the Taihape series is now classified as either the older Pahiatua*f* family or the younger Mahoenui*f* family.

New Zealand – part of GlobalSoilMap.net

What is GlobalSoilMap.net?

A global consortium has been formed that aims to make a new digital soil map of the world. Data for 11 key soil attributes will be modelled for 6 soil depth increments and mapped at 90-m resolution. Values will be provided to 2-m depth, unless shallower, as continuous depth intervals. The initial attributes are soil depth, percent carbon, pH, bulk density, sand, silt, clay, stones, available water capacity, effective cation exchange, and electrical conductivity. Countries may add other desired attributes to this list. In the first version the data will be modelled from available legacy soil data and uncertainty estimates will show where further investments are necessary to improve accuracy.

The project is very challenging technically and is only now possible given recent advances in digital soil mapping techniques. Alex McBratney and Budiman Minasny of Sydney University have been prominent in the development of the science. Another enabling factor has been the recent availability of spatial prediction layers, for example, the global 90-m digital terrain model derived from the NASA Space Shuttle radar mission.

Equally challenging is the organisation necessary to achieve global coordination. GlobalSoilMap.net will be a major IUSS project. See the web site: http://www.globalsoilmap.net/. Good support has been gained from around the globe as it is well recognised that countries, including New Zealand, have much to gain in terms of capability development, the regrowth of the discipline of pedology (in conjunction with informatics), and support for local soil mapping initiatives.

Why is this needed?

We are all aware of the multiple, looming, global issues of climate change, food security, water quality and quantity, environmental contamination, erosion, etc. Science communities involved in modelling these issues are finding a lack of suitable global soil data. Polygon maps at scales of 1:5 000 000 are available but are too generalised, and it is also difficult to extract attribute information from them. The soil science community needs to lift its sights from local concerns and also contribute effectively to the global modelling efforts.

New Zealand activity

New Zealand is part of the Oceania node of *GlobalSoilMap.net*, and New Zealanders are involved in the Oceania and Global leadership. Resulting benefits to New Zealand are likely to be the development of new pedological skills in digital soil mapping, and the ability of our national S-map soil mapping programme to operate in conjunction with the global initiative. The intention is to apply *GlobalSoilMap.net* procedures at finer resolution for local use and deliver a generalised version for the global coverage. S-map is achieving the collation and harmonisation of legacy data as it proceeds so it is setting the stage for *GlobalSoilMap.net* in New Zealand. For the lowlands where S-map has made greatest progress, *GlobalSoilMap.net* outputs can be produced by analysis of soil polygons. It will be in the hill and mountain lands that the digital soil mapping techniques of *GlobalSoilMap.net* will most significantly advance our soil mapping coverage.

There is no external funding for *GlobalSoilMap.net* in New Zealand. Each node and country has to find their own sources. The Bill and Melinda Gates Foundation has contributed to the global administration, and has adopted the work of the African Node. Another American foundation is contributing to the Latin American Node. The North American Node has already completed draft production of the key attribute layers for the continental US – showing what is possible given good resources and good legacy data. We hope that eventually all the territories of Oceania will be adequately funded and that New Zealand will be part of that.

Our role in the Oceania effort will focus on the areas we know best and for which we have significant data sets – the Pacific Islands, Antarctica, and of course the islands of New Zealand.

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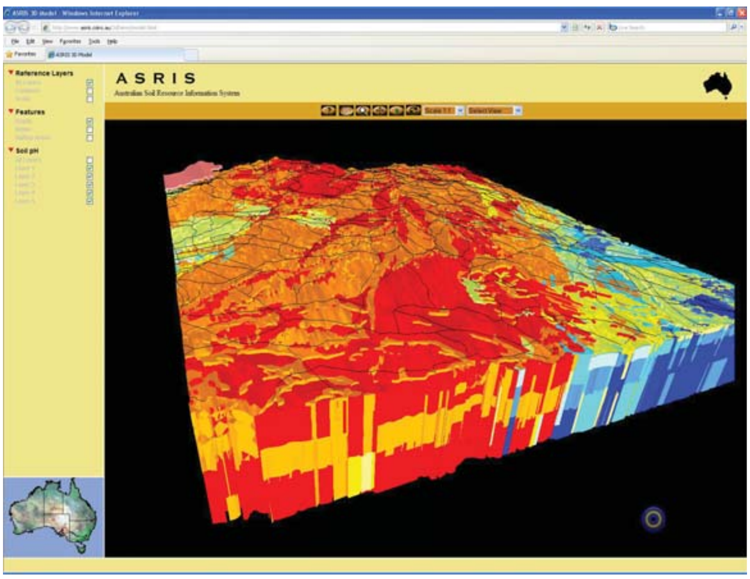

The Global Soil Map will produce a digital 3D map of the world's soils predicting soil attributes such as carbon and texture. This image shows how the variability of properties with depth can be displayed. Credit: CSIRO

Ecosystem Services for multiple outcomes

Communities not only require their environment to provide food and drink but also shelter, livelihoods, lifestyle, and access to goods. These components of human well-being are provided directly and indirectly by both managed and natural ecosystems. This broader approach to natural resource management, which recognises the full range of services provided to humans, is called the ecosystem services approach.

Landcare Research has been contracted by the Ministry of Science and Innovation to conduct a detailed assessment of ecosystem services for New Zealand. The work has three major objectives:

- identify and assess the full range of ecosystem services
- model future land use/management and associated ecosystem services
- establish an ecosystems service framework to be used by policy and management agencies.

It is planned to make the assessments sufficiently detailed to permit the evaluation of real tradeoffs in resource management.

There have been several key achievements in the programme over the last year:

Optimising ecosystem services: A tool for optimising ecosystem services for spatial configuration of land use has been developed using open-source software. An analysis of the conversion of forestry to dairy in the central North Island was completed, and preliminary results suggest that conversion is not always taking place on the most appropriate soil types.

Soil formation and maintenance: The loss of high-class land to urbanisation over the last 20 years has been determined from satellite imagery as 0.5% (7080 h in 1.3 million hectares). This is not high, but in contrast, the proportion of high-class land occupied by small holdings ("lifestyle blocks") at 10% is significant and could impact on national food productivity levels.

Provision of fresh water: National models of nitrate and phosphorus leaching based on soil/climate combinations have been developed. The models are used to produce leaching maps at 1:50 000 scale for any area in New Zealand in response to land use and stocking rates. This level of spatial detail exceeds that of presently existing national models. These models will permit better matching of land-use intensification with soil type.

Provision of natural habitat: Recent trends in provision of natural habitat for biodiversity have been quantified using remote sensing. A national measure for provision of natural habitat has been developed (Figure 1) and used to identify contributions from individual ecosystems.

For more information see www.ecosystemservices.co.nz

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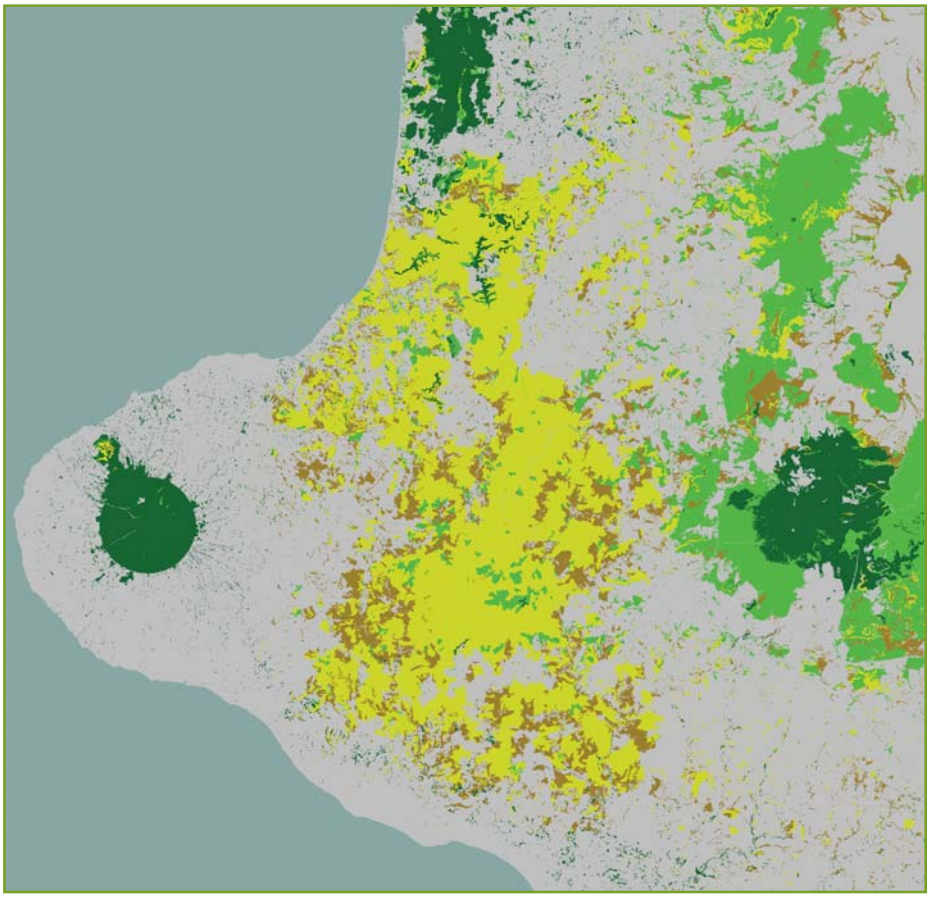

FIGURE 1 The contribution of Taranaki and inland ecosystems to a national measure of natural habitat provision (a supporting ecosystem service): dark green is high; light green is moderately high; yellow is moderate; brown is low; and grey is near zero.

Detecting changes in soil carbon and nitrogen under pastoral land use in New Zealand

We have revisited and resampled the National Soils Database (NSD) sites to compare changes in soil carbon, nitrogen, phosphorus, and pH since archived samples were collected (dating back to 1960s). This current MAF funded SLMACC project complements a previous project where 83 profiles were revisited, and is collaborative with the University of Waikato. It is planned to have re-sampled 200+ sites by June 2012. Forty sites between Southland and the Waikato were visited in the last 12 months, which adds to 83 sites re-sampled in the previous 8 years. All sites were originally under pastoral land use and were also under pastoral land use when re-sampled. As it was not always possible to ascertain that the land use had been continuously pastoral, and for the majority of sites, it was assumed that some cultivation had occurred over the 20–30 years between sampling. Sites that showed evidence of cultivation in the previous 12 months were not sampled.

TABLE 1 Average change in C and N in t/ha/y for 0–30 cm soil; sem in parentheses

Land form	Land use		C	N
		n	Average	Average
Flat	Drystock	54	–0.04 (0.09)	0.002 (0.008)
Flat	Dairy	37	–0.53 (0.14)***	–0.037 (0.014)*
Hill (mid-slope)	Drystock	16	0.48 (0.17)*	0.062 (0.017)**
South Island tussock	Drystock	12	0.00 (0.13)	0.004 (0.009)

(*, **, and *** - significantly different from 0 at P<0.05, P<0.01, and P<0.001 respectively)

Sampling of 119 sites provides evidence that soil C and N stocks had changed over an average 28-year time period between sampling, and that there were land-use effects. Flat dairy land lost significant C and N, flat dry stock land remained unchanged, and hill country dry stock land (with no landslides) gained significant C and N (Table 1). There are a number of hypotheses as to the mechanisms of stock changes, but understanding the role that various land management practices play in loss of C from the soil system is likely to be important in managing and enhancing soil storage. The implications that increasing land-use intensity has on C and N stocks and fluxes are fundamental to managing and enhancing soil C and N, but, as land use intensity is not quantitatively defined, it is not possible to assess loss of C directly against land-use intensity. However, environmental data are being collected to help understand land-use activity and, thereby, intensity. Fertiliser and lime use, stock type, grazing management, farm size, history of tenure, and general farm observations such as pasture species and condition, and the relative location of sites on farm are noted where this information is available.

Data collected in 2010 have continued to support previous findings, although changes under dairy farms are not as large. With 200 points of data representing 11 NZSC Soil Orders (Allophanic, Brown, Gley, Granular, Melanic, Oxidic, Pallic, Pumice, Recent, Semiarid, Ultic) and pastoral land uses ranging from extensively grazed upland tussock to intensively grazed lowland dairy, it is hoped to gain understanding of the factors leading to losses of profile C and N. This will help focus future research into mechanisms that control stocks and fluxes, and may help explain why dairy soils have lost significant C and N over the last 20–30 years.

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Making better use of LiDAR in soil and landscape modelling

LiDAR (Light Detection And Ranging) is a remote sensing technique that uses high-frequency laser pulses to gather information about a surface. A LiDAR survey may contain multiple points per square metre over very large areas with vertical accuracies of 0.15 m or even better, enabling the generation of very high resolution Digital Elevation Models (DEMs).

Barriers to using LiDAR

As technology continues to develop and costs decrease, LiDAR is becoming increasingly widely used in New Zealand and internationally. However, a more widespread uptake of LiDAR in New Zealand has been held back by several factors:

- A lack of understanding of what LiDAR is, and how and when it should be used
- A perception that LiDAR is expensive, especially in New Zealand
- A reluctance by organisations to collaborate and share LiDAR data (often due to cost)
- Consequent relatively poor coordination between organisations, and a poor level of awareness of who has, or is using, LiDAR.

As a result, New Zealand's LiDAR coverage is patchy, mainly project-driven, and raw data are often inaccessible to organisations outside those who commissioned and paid for the original surveys. There is also a lack of consistency as to the level of specification at which LiDAR surveys are acquired, meaning that not all existing LiDAR data are equally suitable for different applications. Additionally, the rapid increase in LiDAR scanner technology, particularly regarding the operating frequency of a modern scanner (as high as 250 kHz, or 250 000 outgoing pulses per second), means that even a small LiDAR survey can now contain many millions of data points – which places great demand on software and computing resources when it comes to processing such large datasets.

So why bother with LiDAR?

Being an active rather than a passive technique, high-quality LiDAR data can be acquired under cloudy skies or low sun angles, unlike aerial photography. LiDAR is also able to "see" through some vegetation canopies, providing a valuable source of elevation data for vegetated areas that would otherwise be obscured on photogrammetrically derived DEMs. LiDAR surveys produce extremely dense and accurate elevation data, making them ideal for mapping and modelling landscape and vegetation attributes at resolutions far higher than previously possible. LiDAR data are also immune to the effects of poor image texture in aerial imagery – which, along with interference by vegetation, can be a major limitation on the quality of photogrammetrically derived "bare earth" DEMs.

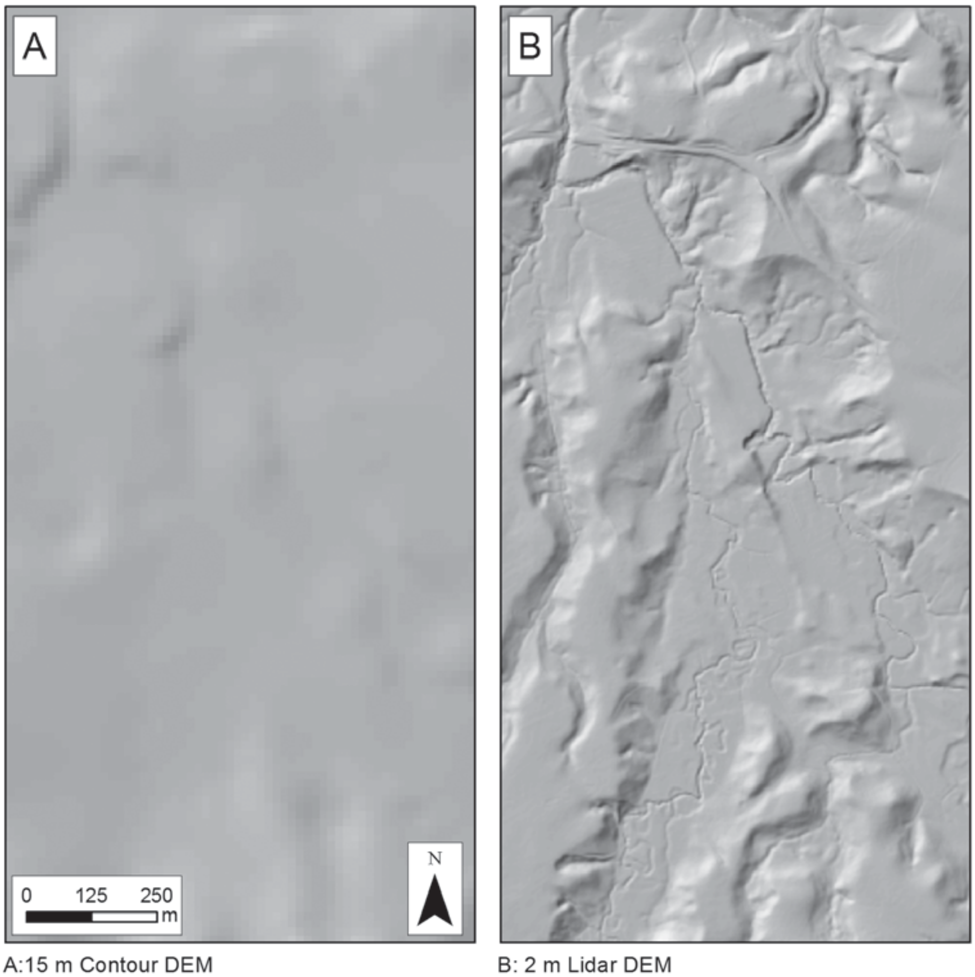

FIGURE 1 Shaded relief views of 15 m contour-based DEM (Panel A) and the equivalent 2 m LiDAR DEM (Panel B). Note the far higher level of landscape detail on the LiDAR DEM. (Raw LiDAR data courtesy of Environment Waikato.)

Figure 1 shows an example of how a 2 m resolution LiDAR DEM (for part of the Waitetuna catchment, south of Raglan Harbour) compares visually with Landcare's existing 15 m national DEM (based on 20 m contour data). Figure 2 contains slope layers calculated from these DEMs. There is no question that the LiDAR DEM contains far more landscape detail than the contour-based DEM, particularly in low-relief areas where 20 m contour spacing is generally wide, with a corresponding lack of detail in contour-based DEMs.

Having national-scale, high-quality LiDAR data would be of enormous benefit to environmental research and management in New Zealand. Such data would support very high-resolution mapping and modelling work, which is becoming more feasible at large scales thanks to ongoing rapid improvements in data processing and storage. The availability of very high-quality environmental data and information would ultimately support more robust regional and national environmental policy decisions.

How could we make better use of LiDAR in New Zealand?

Recognising the opportunity that LiDAR represents for improved landscape mapping and modelling in New Zealand, Landcare Research is undertaking the following in response to the barriers to the uptake of LiDAR uptake identified above:

- We intend to canvass special interest groups such as regional councils, forestry groups and central Government (the latter via the NZ Geospatial Office) to determine whether there is national support for a NZ-wide LiDAR coverage
- We are developing a set of open-source software tools (based mainly on GRASS, a leading open-source GIS software package), that will be capable of utilising Landcare's high-performance computing capabilities. This will enable us, quickly and efficiently, to generate high-resolution DEMs and DEM derivatives such as slope, aspect, and hydrological indices directly from very large LiDAR datasets. This facility could also be used, along with our own expertise, to process LiDAR data for third parties
- As part of Landcare's proposed National Land Resource Centre, we could potentially act as a custodian for a national-scale LiDAR dataset, using our newly developed capability to process and "serve up" LiDAR-based DEMs and DEM products on demand, as well as working to improve the consistency and quality of metadata for LiDAR data nationwide.

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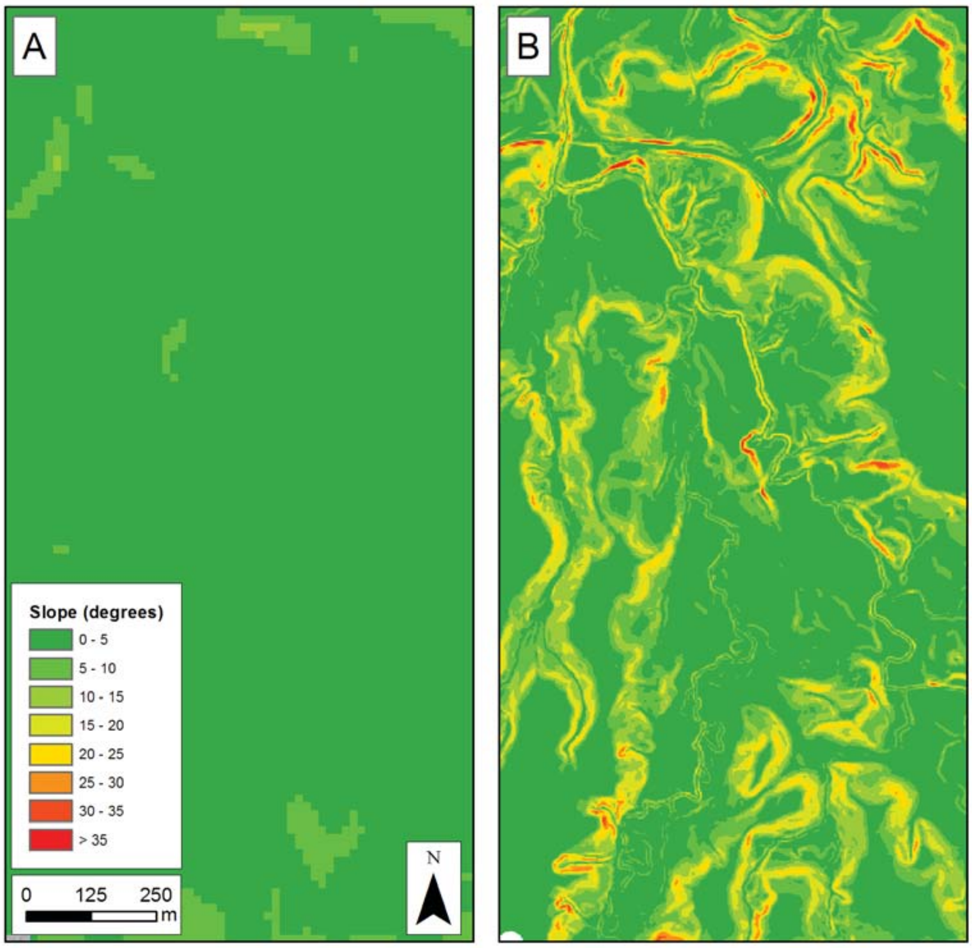

A:15 m Contour DEM
B: 2 m Lidar DEM

FIGURE 2 Slope layers generated from 15 m contour-based DEM (Panel A) and the equivalent 2 m LiDAR DEM (Panel B). The LiDAR DEM would clearly be much more useful for high-resolution erosion applications requiring slope information, such as erosion and soil-landscape modelling. (Raw LiDAR data courtesy of Environment Waikato.)

Tracking the depth to water table in the Manawatu Sand Country

We are using a wireless network of sensors installed in the ground to monitor soil moisture and depth to water table at our research site in the Manawatu Sand Country. Information is transmitted every 15 minutes from the sensors to a base station and from here to a website. We are also using soil survey gear that uses very accurate GPS (centimetre accuracy) in conjunction with an electromagnetic (EM) sensor to map soil electrical conductivity at very high resolution. The high resolution soil map is used with the water table data to model depth to water table accurately at any one position. This information is used for precision irrigation scheduling.

The Manawatu Sand Country, the largest area of coastal dunes in New Zealand, is a complex of sand dunes and plains, peat swamps and lakes. Early development of these soils was hampered by wind erosion, and variably high water tables. However, the introduction of forestry onto sand dunes, and minimum cultivation and controlled drainage of sand plains are enabling successful agricultural development of this region. Depth to water table does vary in the undulating sand plains, with freely draining hydrophobic areas frequently occurring next to low-lying zones with high water table that remain relatively wet into the late spring, inhibiting plant establishment.

Excessively high water tables can be controlled to some extent by insertion of drainage channels to maintain the subterranean freshwater resource at an optimum depth of about one metre below the bottom of the root zone. However, the undulating and variable nature of the terrain still results in significant depth differences to the water table in any one irrigated field. Where precision irrigation scheduling is employed, these site-specific differences need to be addressed. We have therefore developed a method to map and monitor varying depths to the water table so that the effect of the water table on soil water status and irrigation timing can be managed precisely.

The electromagnetic sensor used in the soil survey measures soil electrical conductivity, which is closely related to soil moisture in these uniformly textured sand soils. Soil moisture, in turn, reflects the depth of the water table at this site. The soil electrical conductivity map is therefore used both to delineate soil moisture zones and to determine where to place sensors to monitor water table depth. We have used the EM survey and rainfall data to develop a mathematical model to accurately predict depth to water table (Figure 1).

The ability of our wireless sensor network to monitor water table and soil moisture simultaneously provides direct information about the amount of plant-available water. Our research, in collaboration with Massey University, continues to develop this method for real-time variable rate irrigation scheduling.

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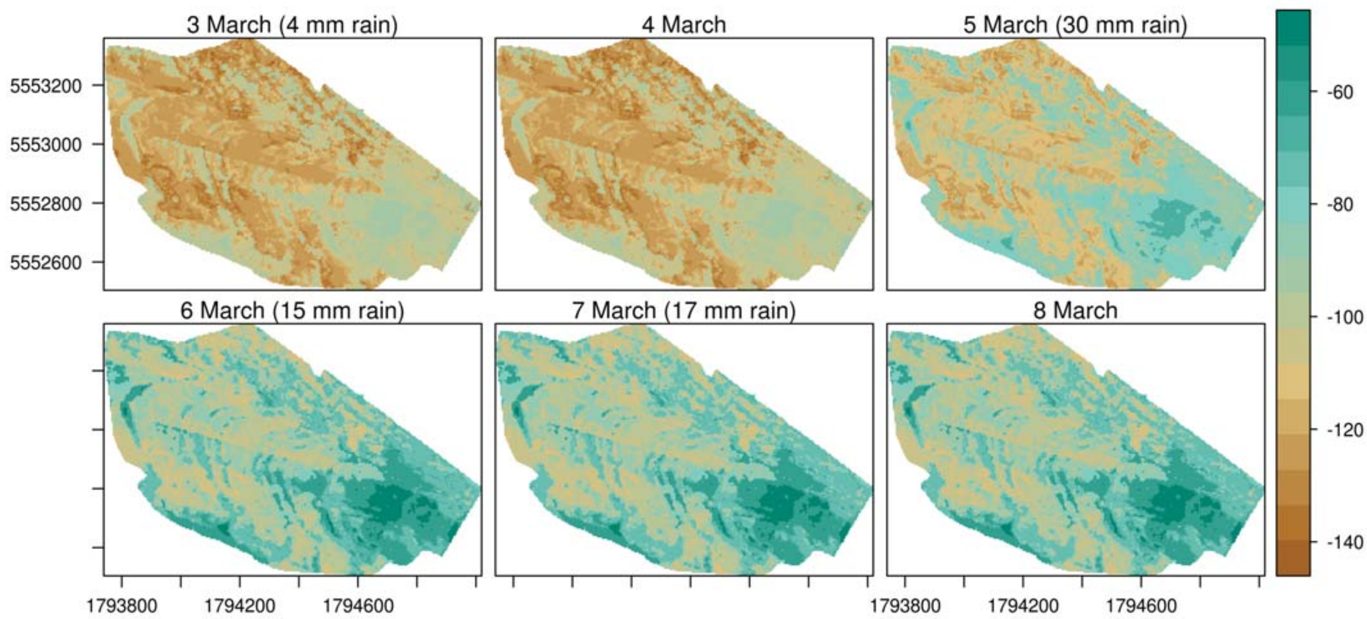

FIGURE 1 Maps to show depth to water table (cm) for a 6-day period (3–8 March) in a 75-hectare irrigated maize field in the Manawatu Sand Country.

Effect of erosion on soil carbon stocks

Since the development of the Soil Carbon Monitoring System (Soil CMS) to predict soil carbon stocks, it has been recognised that mass movement erosion potentially has a major influence on these stocks. The Ministry for the Environment has recently funded a pilot project to collect field data to address this issue. Soils were sampled at a series of plots with extensive landslide and gully erosion (Figure 1), and the extent of changes in erosion was mapped to determine the effect of erosion on soil carbon over the last 40 years.

TABLE 1 Comparison of measured soil C stocks with Soil CMS model predictions

Erosion type	Site	Measured soil C stocks (t C ha–1)			
		Average uneroded plots	Average eroded plots	Net stocks corrected for erosion	Soil CMS model (t C/ha)
Landslide	Te Whanga	102	65	89	104
Landslide	Tutira	111	61	88	104
Gully	Tapuaeroa grassland	124	NA	119	119
Gully	Tapuaeroa forest	113	39	108	102
Gully	Brigadoon forest	63	20	60	102
Gully	Te Weraroa forest	65	19	57	98

Landsliding had a significant effect on soil properties and soil carbon stocks; since the late 1930s it had affected about 50% of a hillslope area at two study sites – Te Whanga in the Wairarapa (Figure 1) and Tutira in Hawke's Bay hill country. Soil carbon stocks (0–30 cm) were highest in uneroded soils (about 100 t/ha) and averaged 60–65 t/ha on eroded sites. There were clear differences in soil carbon stocks between landslide scars and debris tails, and a trend for soil carbon to increase as landslide age increased. After about 70 years, soil carbon stocks were still well below the value measured for uneroded plots (by about 40% for scars and 20–30% for debris tails), indicating the effect of erosion is very persistent. When the effect of landslide erosion is incorporated into the calculation of soil carbon stocks both sites had about 90 t/ha (Table 1), compared with an estimate of 104 t/ha from the Soil CMS model.

By contrast, gully erosion had a minor influence on soil carbon stocks. While active gullies and reforested gullies have much lower soil carbon stocks (<30 t/ha), they are minor components of the landscape (generally <5% of the area) and therefore have little influence at whole-landscape scale.

At the study sites there was little change in estimated soil carbon stocks between 1990 (the baseline year for Kyoto Protocol reporting) and 2008 because most of the landsliding had occurred before 1990. However, of the total soil carbon stocks at Te Whanga, 41% are stored on 1977 landslides, while at Tutira, 52% of the total stocks are stored on 1988 landslides, implying major storm events in affected areas have the potential to reduce soil carbon stocks significantly. The results indicate that the Soil CMS model overestimates soil carbon stocks for steep eroding hill country where landsliding is extensive. At Te Whanga the net reduction in soil carbon stocks due to landsliding was about 13% and at Tutira it was about 21%.

FIGURE 1 Extensive old landslide erosion at the Te Whanga site.

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Protecting coral reefs in the Pacific

News media report regularly on the threats to coral reefs from climate warming. However, sedimentation from adjacent catchments onto near-shore coral is a more visible impact for Pacific Island communities who rely on these coral reefs for fish, tourism, and maintaining traditional cultural values.

Landcare Research scientists Andrew Fenemor, Colin Meurk and Grant Hunter have led the compilation of a Best Practice Guide for community action and revegetation in Pacific Island hill lands to support community initiatives to protect coastal resources. The Guide was developed for the French-funded Coral Reef InitiativeS for the Pacific (CRISP) and co-authored with experts from the University of the South Pacific (USP), Secretariat of the Pacific Community (SPC), Vanuatu Farm Support Association (FSA), and Fiji Department of Forestry.

The project aims to allow communities to undertake sustainable management decisions in the protection and restoration of their watershed (i.e. catchment) areas. It applies an integrated catchment management (ICM) ridge-to-reef approach highlighting the connectivity of land-use practices in the upper catchment and their impacts in the marine environment. The Guide particularly draws on USP and FSA work with communities in the Naroko and Nakorotubo catchments of north-east Viti Levu (Fiji) and in Epau and Aneityum in Vanuatu; however, the principles apply to any Pacific hill lands.

There are two parts to the Guide: the first part provides information on ICM processes from the Motueka catchment (http://icm.landcareresearch.co.nz) and planning revegetation projects for catchment recovery (http://www.landcareresearch.co.nz/services/greentoolbox/); the second part includes lists of Pacific species suitable for revegetating hills, floodplains, and coastal and stream margins.

The Guide offers a step-wise process for agencies and local communities to manage their sediment loss:

1. engaging communities and raising awareness
2. identifying problems and vision as part of a planning process
3. identifying erosion risk according to simple, easily applied field criteria, recognising where in the landscape these risk classes occur, based on land units on maps and oblique aerial photographs, and ecologically characterising these land units
4. providing a selection of (safe) species suitable for each named land unit, and providing choices among the selection according to use value (timber, building, crafts, fibre, medicine, pasture, crop/food, and biodiversity) and propagation process
5. applying planting and maintenance techniques that ensure best result for effort and resources, and
6. carrying out a monitoring regime and learning from the process through an adaptive management cycle.

BEST PRACTICE GUIDE FOR WATERSHED MANAGEMENT IN PACIFIC ISLANDS

PART 1 – PRINCIPLES FOR ACTION

1. Scale of the problem
2. What can I control and what can't I control?
3. Why use a watershed approach?
4. Principles for Integrated Watershed Management
5. Mobilising commitment
6. Reducing soil erosion and sediment delivery to the coast
7. Best practice revegetation

PART 2 – A PROCESS FOR IMPLEMENTATION

8. Planning
9. Implementation in the field (project management and plant preparation)
10. Site preparation
11. Planting
12. Maintenance (follow-up establishment and tending)
13. Monitoring – evaluation and adaptation to ensure successful and enduring outcomes

The Guide can be downloaded from: http://www.crisponline.info/Portals/0/New%20reports/ENG%202010%20Best%20practice%20guide%20watershed%20management.pdf

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Mapping Antarctic soils

The Antarctic environment and its soils are protected by international treaty that gives freedom for scientific investigation and sets stringent standards of environmental protection. This provides a framework for Landcare Research's involvement in a number of projects, which include our current emphasis on producing soil maps so that any future decisions are well informed.

FIGURE 1 View westwards along Wright Valley from Goodspeed alpine glacier on Christmas Day 2010. Note alpine glaciers on the south wall of the valley and the inland flowing Onyx River in the valley bottom.

The total ice-free area of Antarctica is less than 0.4% of the continent, and soils can develop in 90% of these ice-free regions, which occur mainly on the coast, particularly on the Antarctic Peninsula and in the McMurdo Dry Valleys in the Ross Sea Region. An example of a dry valley, the Wright Valley, is shown in Figure 1.

Soil data are deposited in our Antarctic soils database, which is part of the New Zealand National Soils Database (NSD) – a nationally significant database – managed by Landcare Research. The database contains historic data collected by Drs Iain Campbell and Graeme Claridge from the 1950s to the 1990s plus more recent data. Descriptions of over 1000 soil pits are included in the database. For each soil pit, site and soil horizons are described in detail. Site descriptions include observations of the surrounding geological, topographic and climatic contexts, and local surface features, site moisture, parent material, and biology.

We have been mapping soils in the Ross Sea region using soil landscape models, with fieldwork for validation. Information used includes: soil descriptions; high resolution electronic Light Detection and Ranging (LIDAR) data; high resolution satellite images and stereo air photo pairs to give detailed 3D images of the landscape.Our soil map of the Wright Valley (Figure 2) shows the patterns of soil development.

Our Antarctic soils maps have many applications, including:

- providing a spatial framework for environmental management including impact assessment and reporting
- rating soil vulnerability to human impacts (e.g., foot traffic or hydrocarbon spills)
- aiding selection of sites for experimental work
- assisting with planning for campsites and fieldwork sites that minimise impacts
- defining sites that require further protection.

This research is being conducted collaboratively with Professor James Bockheim (University of Wisconsin, Madison, WI, USA) and Dr Megan Balks (Waikato University).

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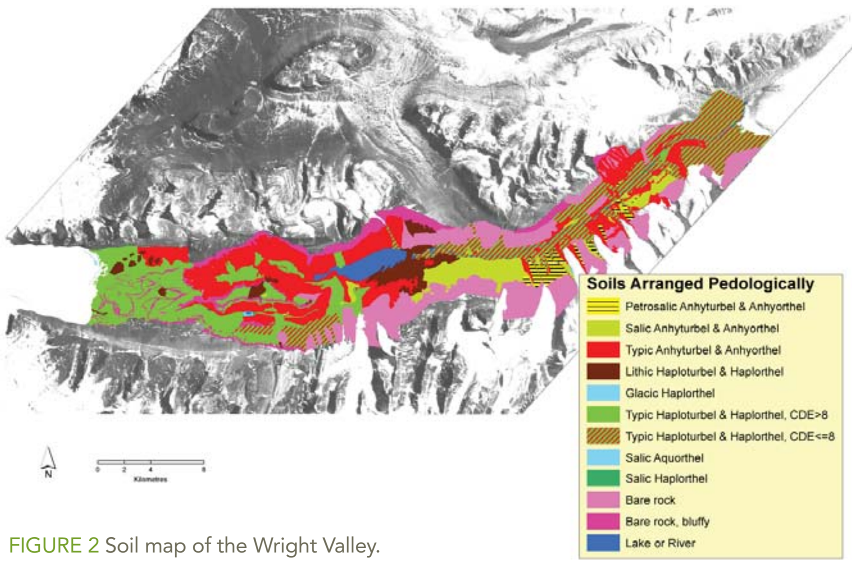

FIGURE 2 Soil map of the Wright Valley.

New editions of the NZ Land Cover Database

How and where is land cover in New Zealand changing through time? What are the major characteristics of this change? These two key questions will be answered by new editions of the New Zealand Land Cover Database (LCDB).

LCDB is a digital map of the surface of New Zealand created using satellite imagery. It contains detailed information on categories of land cover and boundaries, and is a record of land-cover changes over time.

Two completed editions (LCDB1 and LCDB2), which show the state of New Zealand's land cover in 1996–1997 and 2000–2001 respectively, have become critical to central, regional and local government, industry and research institutions. The information is used for land, water and biodiversity management, pest control and monitoring, wildfire threat and risk analysis, and environmental monitoring and reporting.

The creation of new land-cover databases and related research has been identified as an important priority by the Ministry for the Environment (MfE), Department of Conservation (DOC), and regional councils. Landcare Research has been commissioned to deliver two further editions of LCDB and a parallel research programme that will develop improved ways of generating land-cover information.

LCDB3 will be derived from the 2008 satellite imagery used for the MfE Land Use & Carbon Analysis System (LUCAS) and delivered in July 2012, while LCDB4 will use 2012 LUCAS imagery and will be delivered in July 2014.

"This project will answer key environmental research questions about how land cover is changing," says Project Leader, Peter Newsome. "This research has spin-off benefits for other applications that require spatial analysis and classification of imagery – ranging from the monitoring of sustainable land use, habitat analysis, agricultural applications, economic modelling, to disaster response planning.

"Our goal is that by 2015 end-users will have access to a well-established series of LCDB editions that provide the authoritative record of land cover and land-cover change in New Zealand. We expect these datasets will be widely used to support decisions on land use, along with monitoring and reporting requirements.

"Landcare Research will then have an effective methodology, and the experience and user support, to take the series into the future, with a land-cover classification that utilises the most appropriate satellite imagery available."

The project is collaborative, with contributions from the MfE, DOC, MAF, and regional councils.

The development of LCDB3 and LCDB4 is largely being funded by Ministry of Science and Innovation, with financial support also from MfE, DOC, MAF and regional councils.

Modified from press release on www.landcareresearch.co.nz/news/release.asp?Ne_ID=314

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