New Zealand Society of Soil Science

Soils2018 Conference

"DIVERSE SOILS - PRODUCTIVE LANDSCAPES"

www.nzssconference.co.nz

3-6 December 2018
Napier Conference Centre

CONFERENCE HANDBOOK

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Thank you to all our sponsors.
This conference is made possible only through the commitment of many individuals and groups.

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ARL provides a range of soil testing options as well as plant and water analysis. ARL has a strong agricultural focus and capacity to manage bulk work for research requirements.

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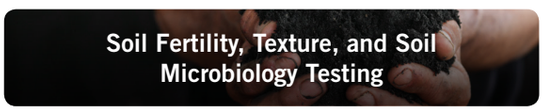
Eurofins Agricultural testing service has provided analytical testing to the Agricultural and Horticultural sectors in New Zealand for over 30 years.

Eurofins Agricultural takes pride in providing a **totally independent science-based service** to Soil Researchers and Consultants to meet the industry's needs.



Eurofins Agricultural testing provides quality analysis. Our service aims to be flexible, meeting our clients' and the sector's testing requirements. We aim to provide a service and knowledge to our clients which goes beyond the laboratory.

We value our partnerships with our clients, and will work together to help grow and develop both your business and our laboratory service. Through the Eurofins Global network, we have access to both advancements in technology and good practices that benefit our clients and complement our services.

Contact our Team for all your testing requirements.

www.eurofins.co.nz
agrinz@eurofins.com
Sarah Stiles-Jones 027 5220 344
Nevan Ofsoski 027 4059 068


HAWKE'S BAY
REGIONAL COUNCIL
Hawke's Bay Regional Council welcomes you to the NZ Soil Science Society Conference.
We take soil seriously in Hawke's Bay because our community depends on it.
Our Land Science team is leading the way in understanding our landscape and soils. This will help us protect our land, water and coast for future generations.
Talk to our Land Science team, Barry, Tim and Jamie, about our work in Hawke's Bay.

PRESIDENT'S WELCOME

As President of the New Zealand Society of Soil Science I am delighted to welcome you to our biennial conference located in Napier themed around 'Diverse Soils – Productive Landscapes'. This conference provides an opportunity for our society's diverse membership (researchers, students, academics, policy makers, consultants and advisors) to share ideas and latest finding related so soil science and land use.

The food production centre of the Hawkes Bay with its wide and varied landscapes provides the ideal location to demonstrate a large diversity of land uses encompassing horticulture, viticulture, arable, forestry and pastoral that make use of the productive capacity on offer. Holding the conference in the Hawkes Bay provides an opportunity to bring our membership to the regions where through keynote/plenary presentations, field trips and presentations from local researchers we can gain a better understanding of the issues and challenges being faced and the solutions available through robust application of soil sciences.

It is pleasing to see the large numbers of students who have enrolled at the conference and who will also be presenting. It goes without saying that students are the future of both our society and our profession and so the NZSSS places great importance in helping support their involvement. In addition these biennial events are important for sharing knowledge amongst our soil science community. Therefore I would encourage all delegates to make good use of the breaks in our programme, field trips and various social events to meet new people, make new connections and ideally create new future collaborations.

Finally I would like to acknowledge the effort made by our local organising committee (led by co-convenors Paul Johnstone and Rebecca Withnall) in bringing this conference together. There is a lot of work that goes on behind the scene in order to make events such as this run smoothly.

Dave Houlbrooke
NZSSS President

WELCOME

New Zealand Society of Soil Science

Kia ora and welcome to Soils 2018 – Diverse Soils – Productive Landscapes. This biennial conference has been jointly organised by the NZ Soil Science Society and OnCue Conferences, and will cover a diverse range of topics. The wider Hawke's Bay region is home to a diverse mix of primary production, from forestry and sheep and beef production on the coastal and northern hill country, intensive dairy systems on the flat and rolling terraces abutting the ranges, to highly productive horticulture and cropping on the fertile Heretaunga and Ruataniwha plains. During this conference you'll get a chance to hear from a wide range of researchers, industry leaders, consultants and advisors, regulators and land managers on all things soils related, anchored by a range of exciting keynotes focused on soilscapes, food production and hot topics around water use and environmental indicators.
We hope you enjoy the great venue, the new Napier War Memorial Conference Centre, with amazing views across to Cape Kidnappers. Around the conference you'll have a great chance to connect with your colleagues during a range of social activities at some of the Bay's well known wineries, and look at a wide range of offerings from our event sponsors.

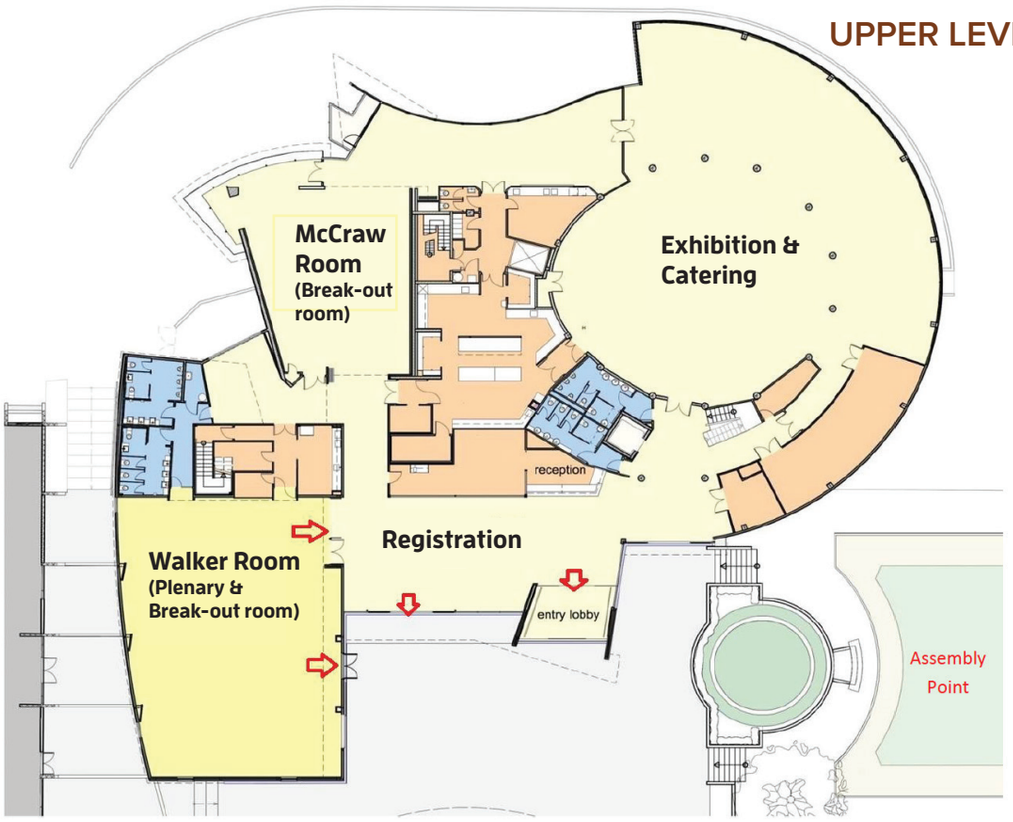
Paul Johnstone and Rebecca Withnall
Co-convenors

Organising Committee

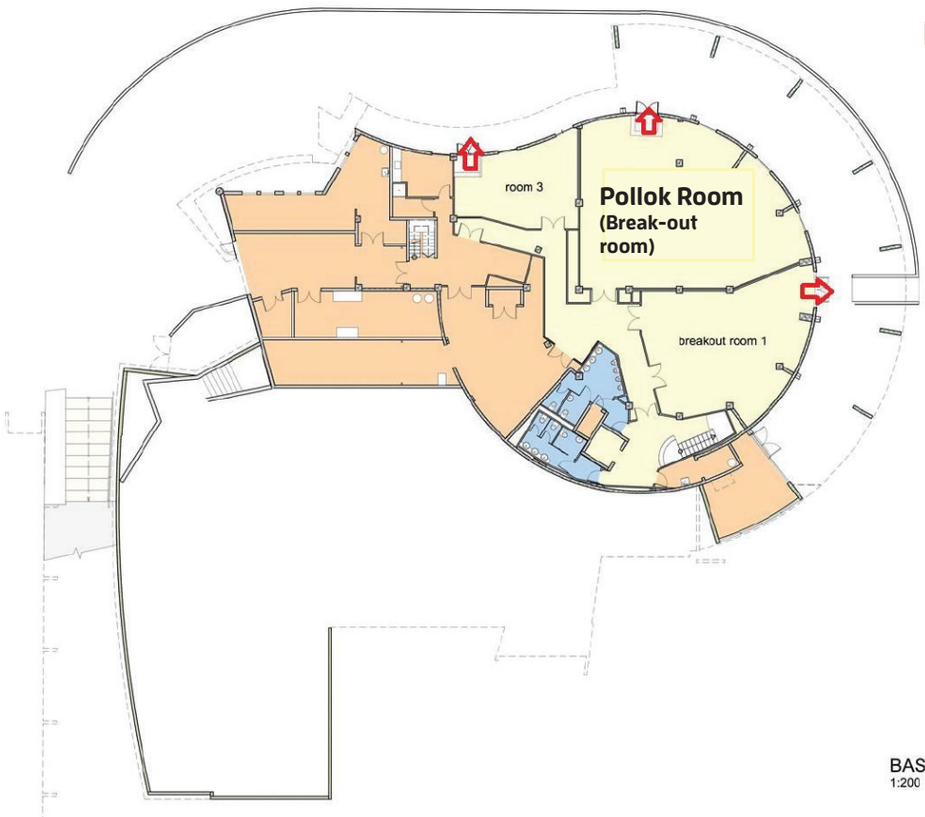
- **Paul Johnstone – Plant & Food Research**
- **Rebecca Withnall**
- **David Houlbrooke – AgResearch**
- **Barry Lynch – Hawke's Bay Regional Council**
- **William Bodeker – ARL**
- **Reece Hill – Waikato Regional Council**
- **Diana Selbie – AgResearch**
- **James Hanly – Massey University**
- **Matthew Norris – Plant & Food Research**
- **Carolyn Hedley – Landcare Research**
- **Stewart Field – EIT**

VENUE FLOOR PLAN

UPPER LEVEL



LOWER LEVEL



BASEMENT FLOOR PLAN
1:200

EMERGENCY INFORMATION

In the event of an emergency you will hear an alarm at the venue, please follow staff instructions, evacuate the building and assemble on the grass area in front of the Floral Clock on Marine Parade.

In the event of an earthquake, stop, drop and cover. When the shaking stops make your way out of the building to the assembly point.

This information will be covered each day in conference housekeeping, preceeding the Keynote presentation.

GENERAL INFORMATION

Registration Desk

If you require any assistance throughout the conference please see the conference organisers at the Registration Desk in the foyer.
A Conference Notice Board will be placed at the Registration Desk and will be used to display conference information, programme changes, announcements and messages. Please check the board regularly.

Internet

Wireless internet broadband is provided free to conference delegates, The network is Napier Conference Centre & accept terms to access

Name Badges

Delegates are requested to wear their name badges to all sessions and social functions. Student helpers will be wearing green lanyards.

Cell Phones

Please ensure that cell phones are turned off, or silent, during all presentations.

Parking

Car parking is available in the 3 hour car park situated behind the Ocean Spa Complex. Access is off Marine Parade 400m north of the Centre. All day and multi-day car parking passes are available at the centre's reception for attendees. Please note that street parking areas are 2 hours only. Parking on the forecourt at the front of the venue is for unloading and loading only.

No Smoking

There is no smoking allowed inside the venue.

Contact Number

For assistance during the conference please call Lea from On-Cue Conferences on **021 117 0916**

Public Transport

Taxis

Hawkes Bay Combined Taxis
Phone: 06 835 7777
The Napier Airport is approx. 15 minutes' drive from the Napier Conference Centre.

Meals

All catering will be in the exhibition area.
If you have advised us of your special dietary requirements, these have been forwarded to the caterers and will be available on a separate table individually marked.
At the Conference Dinner, please make yourself known to the waiting staff and they will make the necessary arrangements for your special meal. If you have any dietary requirements that we are not aware of, please see the Conference Organisers at the Registration Desk on arrival at the conference.

Loading Presentations

Please load your presentation at the Registration Desk – this should be done at least two sessions prior to your scheduled presentation session time.

Poster Presenters

Posters must be displayed before 10am on Monday 3 December. Poster boards are in the Ball room – velcro dots will be provided. Please ensure you are at the poster session by 2.45pm on Wednesday.

Session Chairs

Please can all session chairs be in their room at least 10 minutes prior to the start of the session. Please familiarise yourself with the AV equipment. If you have any questions, locate the student helper or AV technician, who will be close by. It is very important that presentations do not run over their allocated total of 20 minutes so please ensure presenters start and finish on time. If people want to move rooms during sessions they should do so at the start of the 3-minute question/discussion part of the presentation.

Conference App

The app enables you to:
View the latest programme, abstracts, receive official announcements and create a personalised schedule. Access these features and more in the conference app, using your smart phone, tablet or computer.

App Login Details:
1) Go to the app/play store and search for **eventsair**
2) Once downloaded, enter the event code **nzsss2018 & submit**
3) Login: your email address Password: The PIN on the back of your name tag

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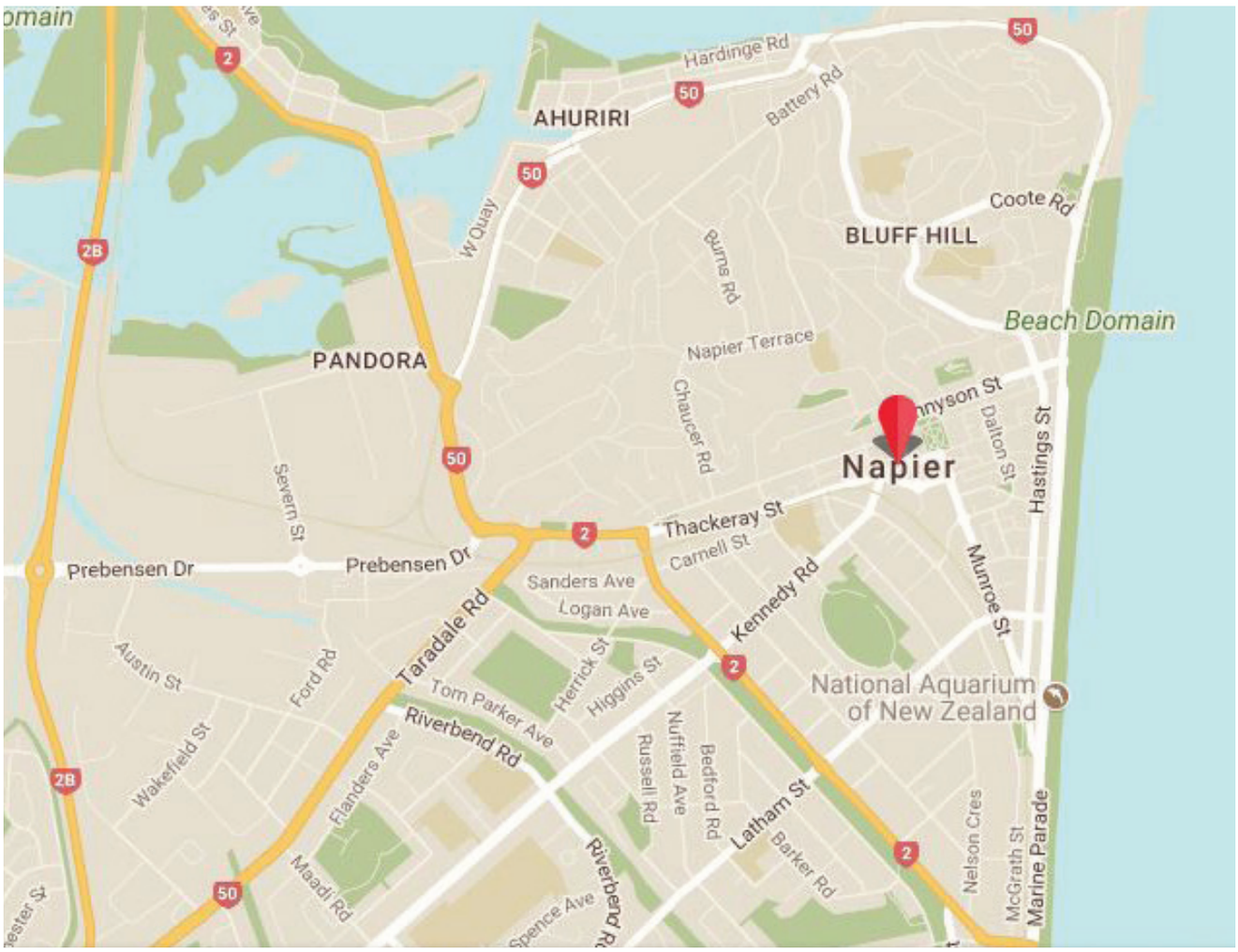
NAPIER CITY MAP



NAPIER INFORMATION

Medical

New Zealand Emergency Services :
Ambulance, Fire and Police. Dial 111 from any public or private telephone or mobile phone in New Zealand.

Napier Police :
Phone 06 831 0700 from within Napier. The police station is located at 135 Dalton Street, Napier

Napier Hospital :
Elmwood House-Hospital:
44 Nelson Cres, Napier South, Napier
Phone 06 834 4048.

Napier Doctors and Medical Centres :

- The Doctors Napier
  30 Munroe St, Napier South, Napier
  06-835 4696
- Greendale Family Health Centre
  135 Gloucester St, Greenmeadows, Napier
  06 844 8071
- HBDHB Napier Clinic
  Napier Health Centre 76 Wellesley Rd, Napier South, Napier
  06 834 1815

Chemist/Pharmacy
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Address 76 Wellesley Rd, Napier South, Napier
Phone 06 835 0046
Hours 9am – 9pm every day

PLAN YOUR VISIT

RESTAURANTS

1. **The Emporium**
   Address: Corner of Tennyson Street & Marine Parade
   Phone: 06 385 0013

2. **Thai Hutt**
   Address: 255 Marine Parade
   Phone: 06 834 3868

3. **RASOI**
   Address: 125 Marine Parade
   Phone: 06 835 4494

4. **Mr D's**
   Address: 47 Tennyson Street
   Phone: 06 835 5022

5. **Hunger Monger**
   Address: 129 Marine Parade
   Phone: 06 835 97 36

THINGS TO DO

Wine Tours

The Hawke's Bay vineyards are all within a short distance of Napier and Hastings, with over 30 open to the public for wine tasting. Many also operate cafes and restaurants in both indoor and outdoor settings. The region is especially known for its fine chardonnay and cabernet sauvignon varieties. Two of the best wineries close to the Scenic Hotel are Church Road Winery and the Mission Estate.
www.churchroad.co.nz and www.missionestate.co.nz

Visit Cape Kidnappers

Discover the magic of Cape Kidnappers – join our experienced guides and visit the largest mainland gannet colony in the world!
The unique, fun eco-experience tour involves travel with local experienced guides by vintage tractors and trailers on a comfortable four-hour adventure to the largest mainland gannet colony in the world!
For more information visit www.gannets.com/tour/

Art Deco Tours

Discover the Art Deco Capital with Napier's official, most experienced and longest running tour operator.
With a range of tour options available all year round, you will find an Art Deco Trust tour to suit you during your time in Napier. Visit www.artdeconapier.com/shop/Tours

MTG Hawke's Bay

At MTG Hawke's Bay you can experience exhibitions sharing local, national and international stories. The museum features a 1931 earthquake exhibition and the region's stunning Taonga Māori, alongside changing exhibitions of art and Hawke's Bay's social history. The Museum is free to enter and located in the heart of Napier two minutes walk from the Napier Conference Centre. Visit www.mtghawkesbay.com

Sea Walls: Artists for Oceans

View almost 50 large scale murals in the Napier CBD and seaside village of Ahuriri painted by internationally renowned artists about pressing issues that face our oceans. Brought to you by Pangeaseed Foundation and Napier City Council. Visit www.pangeaseed.foundation/sea-walls/

SOCIAL FUNCTIONS

WELCOME BBQ FUNCTION

Kindly sponsored by Ravensdown

Monday 3 December 2018
5:30 - 7:30pm

Venue : Napier Conference Centre
Dress : Casual
Tickets : Please see the On-Cue Team at the Registration Desk

An invitation is extended to all delegates to attend the Conference BBQ Function. Renew old friendships and make new acquaintances as we welcome you to Napier.

STUDENT FUNCTION

Kindly sponsored by Plant & Food Research

Tuesday 4 December 2018
6:00 - 7:00pm | 7:00pm onwards drinks and nibbles

Venue : Par2 MiniGolf - drinks and nibbles at Monica Loves Bar
Dress : Casual
Tickets : Please see the On-Cue Team at the Registration Desk

This social evening is always enjoyed, open for all students to attend.

CONFERENCE DINNER

Kindly sponsored by Ballance Agri-Nutrients Limited

Wednesday 5 December 2018
6:00pm buses depart conference centre
6:30pm pre-dinner drinks
7:00pm dinner starts
10:30pm buses start departing dinner back to conference centre until midnight

Venue : Mission Estate Winery - 198 Church Road, Napier, Hawke's Bay
Dress : This year we have an optional dress-up theme for the conference dinner - "1920s" which fits perfectly with Napier being the Art Deco capital!
For costume hire visit, Tabard Theatre Costume Hire
Coronation Street, Ahuriri, Napier
Ph/fax: (06) 835 8775
Opening Hours: Tuesday to Friday: 12pm – 6pm & Saturday: 10am – 3pm
Tickets : Please see the On-Cue Team at the Registration Desk

Join your fellow conference delegates to enjoy a special night out at one of Napiers award-winning wineries.

Manaaki Whenua
Landcare Research

Science for Our Land and Our Future

Manaaki Whenua – Landcare Research is the Crown Research Institute for our land environment. Our dedicated scientists, researchers and experts are commited to helping New Zealanders understand and live well with this land.

Our land is our future. Tō tātou whenua, mō āpōpō.

Our research looks at the complex inter-relationships that control the response of soils and landscapes to climatic and human-induced pressures, evaluating current risk, and offering sustainable land management and land use options. Our current research capabilities include:

- Soil mapping and land capability assessment
- Soil carbon, nitrogen and trace element cycling, including contaminant loss
- Soil chemistry and physics laboratories, including in-field sensing technologies
- Soil water storage and movement
- Soil health, biology and toxicity assessment and management
- Modelling of soil processes at scales from the soil profile to the nation
- Management of the nationally significant soil data repository, and S-map online website

Kia matomato te tupu a Tāne, a Rongo, a Haumia-Tiketike

Let it be that the land and all its fruits may flourish

KEYNOTE SPEAKER

Annabel Langbein

Author, Publisher and Celebrity Cook

Talk Time: Monday 3 December 11:00am

Kiwi cook Annabel Langbein has made it her mission to inspire and empower us all to eat more seasonal produce and fewer barcodes. Wellington-born Annabel learned to cook from her home economist mother, then left home at 17 to live off the land, cooking over an open fire, trapping possums and jumping out of helicopters to recover live deer. She studied horticulture at Lincoln University and travelled widely before turning to food writing as a career. She has written and self-published 27 cookbooks and co-produced and presented three series of her television show The Free Range Cook.
Today she grows most of her family's food in extensive gardens on the shores of Lake Wanaka. She is a foundation member of the Sustainability Council of New Zealand, has an honorary doctorate in Commerce from Lincoln University and was named an Officer of the New Zealand Order of Merit for her services to food writing in the 2018 Queens Birthday Honours List.

Soil Matters

Celebrating the food we grow is central to everything I do. The chain of goodness begins with healthy soil and finishes with healthy animals, healthy people and healthy environments.

The better the soil, the better the grass, the better the milk. The better quality the milk, the better the yoghurt, cheese, and butter. Ninety five percent of we eat relies on the earth and by looking after our soils we have the ability to promote good health in our populations..

Increasingly our soils are under threat- from urban development, agricultural practices and industry. Degraded soils lack the ability to cope with extreme weather events that are increasingly becoming the norm.

The carbon cycle that enabled life on earth to develop over 500 million years ago is now out of balance. With an excess of carbon in our atmosphere we are now living the consquences of climate change.

Regenerative practices to build retain and promote healthy soils have to be one the best responses to climate change. By doing this we can reduce the carbon in the atmosphere and get it back into the earth. The health of our soils is at the heart of our continued prosperity as a species.

I started making my own compost when I was fourteen, and I also studied horticulture at Lincoln university, but for all this, t's only in recent years that I have started to understand that creating healthy strong soils that will support maximum photosynthesis and enable the uptake of important nutrients takes a lot more than compost.

Join me as I take you through the journey of my garden and explain why soil MATTERS.

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SOIL TESTING

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We've recently developed an easy-to-use app*, so you now have sample submission at your fingertips. Easy!

Test your soil with the 100% NZ owned and operated laboratory making soil testing easier and better.

**App available to approved users only.*

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www.hill-laboratories.com

KEYNOTE SPEAKER *JOINT*

Andrew Waterhouse

University of California

Talk Time: Monday 3 December 11:45am

Andrew L. Waterhouse is a third generation Californian, but moved frequently while growing up, including some years abroad, living in Thailand, Ghana and Iran before attending university. He received his bachelor's in chemistry from the University of Notre Dame in 1977. Having completed his Ph.D. and a postdoctoral research appointment at UC Berkeley, he joined the chemistry department at Tulane University in 1986.

In 1991, he moved to the Department of Viticulture and Enology at UC Davis where his research program has delved into various aspects of phenolics. These naturally occurring compounds, present in grape skins and seeds and extracted from oak barrels, account for several aspects of flavor and bouquet, as well as antioxidant activity, which helps wines age and may reduce chronic disease in wine drinkers. Current studies focus on several aspects of wine oxidation chemistry, closure performance and the absorption and metabolism of proanthocyanidins. His graduate students and post-docs are winemakers, researchers and professors across California and elsewhere around the globe.

He is a Professor of Enology and has previously held the John E. Kinsella Chair in Food, Nutrition and Health, and the Marvin Sands Endowed Chair. He has won the Medical Friends of Wine Research Award, a UC Davis Chancellor's Fellow award, holds an honorary doctorate from the University of Bordeaux, and he has been named one of the most highly cited researchers in agriculture by ISI. He teaches a course on the chemical analysis of wine, as well as a graduate course entitled "Natural Products of Wine." He also has an appointment at the University of Auckland as Honorary Professor.

In addition to his research and teaching, Professor Waterhouse is the Co-Editor in Chief of the Journal of the Science of Food and Agriculture, and has chaired numerous national and international symposia and participates in such professional organizations as the American Society for Enology and Viticulture and the American Chemical Society. At UC Davis he has served as Chair of the Department of Viticulture and Enology, Chair of Graduate Council and in other roles

Mark Shepherd

Lead Researcher, AgResearch

Talk Time: Monday 3 December 11:45am

Mark Shepherd's specialist research area is nutrient management in agricultural systems. He is Leader of AgResearch's 'Digital Agriculture' research programme. This investigates how new and emerging technologies can support farm systems science in developing solutions that help farms achieve (and be able to demonstrate) sustainable food production systems. Other recent projects include: National technical leader for the Pastoral 21 Research Programme, a highly collaborative programme focusing on mitigating N leaching; Project Leader, delivering research for MPI in support of the Sustainable Land Management and Climate Change Programme. He has over 30 years of research, development and extension experience, and a good grounding in the issues, and legislation, relating to agri-environmental interactions, in Europe and New Zealand.

Awards include: Joint winner of AgResearch's inaugural Technology Prize in recognition of contribution to Overseer development, a nutrient budgeting model (2013); New Zealand Soil Science Society's M.L. Leamy Award for the most meritorious contribution to soil science published in the last three years (2016); and Kudos Science Team award for the Pastoral 21 Farm Systems Research (2017).

JOINT KEYNOTE SPEAKERS: ANDREW WATERHOUSE & MARK SHEPHERD

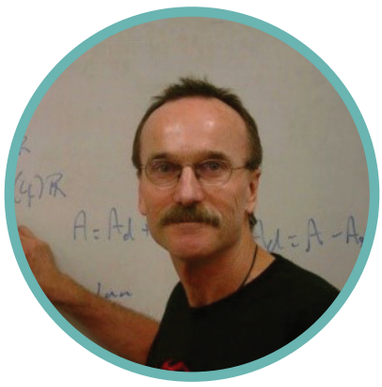
The science behind 'Terroir'

Terroir is an important concept in viticulture and can be defined as the characteristic taste and flavour imparted to a wine by the environment (including factors such as the soil, topography, climate, microbiology and human factors) in which it is produced. The Hawkes Bay wine producing region, with its contrasting soils and landscapes, provides an excellent backdrop to discuss Terroir.

In this presentation, we will describe the soils of Hawkes Bay and the implications for wine growing and provide a review of the science behind the concept of Terroir of wine grapes, otherwise known by the pedestrian term, "site".

Furthermore, we will consider if the concept of Terroir is transferable to other New Zealand food products. The geographic origin of other traditional foods, such as cheese, meat, and honey, is also recognized in Europe. If this could more broadly applied in New Zealand, the concept could be used to define particular high quality sources of particular foods (as with Manuka honey); this would sit well in a future where discerning consumers value specific quality traits as well as the backstory of where and how a food was produced.

KEYNOTE SPEAKER



Dr. Brent Clothier
Principal Scientist, Plant & Food Research
Talk Time: Wednesday 5 December 8:30am

Brent has a BSc (Hons) from Canterbury University and a PhD and DSc from Massey University. Brent is a Fellow of the Royal Society of New Zealand and the New Zealand Society of Soil Science. As well, Brent is a Fellow of three foreign science academies: the Soil Science Society of America, the American Agronomy Society, and the American Geophysical Union. Brent was awarded the Don & Betty Kirkham Soil Physics Award of the Soil Science Society of America in 2000. He was awarded the J.A Prescott Medal by Soil Science Australia in 2001, and the L.I. Grange Medal by the New Zealand Society of Soil Science in 2014.
Brent has published many scientific papers on the movement and fate of water, carbon and chemicals in the root-zones of primary production systems, irrigation allocation and water management, plus sustainable vineyard and orchard practices, including adaptation strategies in the face of climate change. He also published on life-cycle assessment, carbon and water footprinting, environmental policy, investment into ecological infrastructure, plus natural capital quantification and the valuation of ecosystem services. Brent is Editor-in-Chief of the international journal Agricultural Water Management.
Brent has been, or is still involved in water-related aid and development projects in the Pacific and Indian Oceans, as well as in the Middle East and Africa.

Soil, Carbon, and Water: Natural Capital Delivering Valuable Ecosystem Services

Nature comprises an assemblage of natural capital stocks which form our ecological infrastructures. Soils and plants are key components of our ecological infrastructures. They are our prime natural-capital stocks that provide valuable and essential ecosystem services. Of the four ecosystem service classes, we focus here on the two of how soil and plant hydrological processes deliver the provisioning services, along with the regulating services of the buffering and filtering water, carbon, and nutrients. We consider how soil hydrological processes in the saline desert sands of the hyper-arid UAE serve to maintain provisioning and regulating services through irrigation, and especially how alternative water sources can be used to protect dwindling groundwater stocks. We also show how management of avocado trees in the Kenyan highlands regulates the service of soil-water delivery to the trees, and that how an understanding of the regulating services of weather can predict, via a Decision Support Tool, the provisioning service of avocado production. Finally we show how reference to natural capital and the ecosystem services might be incorporated into policy to maintain profitable provisioning services whilst sustaining regulating services. This should also guide us in making land-use decisions for a 'low emissions' economy to mitigate climate change.

KEYNOTE SPEAKER

Simon Upton

Commissioner for the Environment

Talk Time: Thursday 6 December 10:30am

Simon Upton was sworn in as Parliamentary Commissioner for the Environment for a five-year term on the 16th of October 2017.

Mr Upton is a Fellow of the Royal Society of New Zealand and a Rhodes Scholar, with degrees in English literature, music and law from the University of Auckland, and an MLitt in political philosophy from Oxford University. He was sworn in as a member of the Privy Council in 1999.

A Member of Parliament between 1981 and 2000, Mr Upton held a variety of Ministerial portfolios including Environment, Research, Biosecurity, Health and State Services between 1990 and 1999.

After leaving Parliament, Mr Upton moved to Paris to chair the Round Table on Sustainable Development at the Organisation for Economic Co-operation and Development (OECD). In 2005, he returned to New Zealand to pursue a number of private sector roles while continuing to chair the Round Table.

In April 2010 he returned to the OECD full-time as Environment Director, a post he held for seven years until returning to take up the role of Parliamentary Commissioner for the Environment.

New Zealand's soils: Understanding and managing a critical resource

KEYNOTE SPEAKER

Ants Roberts

Chief Scientific Officer, Ravensdown

Talk Time: Thursday 6 December 2:45pm

Ants Roberts many faceted roles involve managing the agronomic research and development projects which are let to a range of research providers including Massey and Lincoln Universities, AgResearch and Plant & Food and assisting in a technical capacity the work which the Fertiliser Association of New Zealand undertakes. He also trains the approximately 70 field staff (who deal on a daily basis with shareholders) and any interested company staff in soils and agronomy. He derives sadistic delight from the setting of tests, both for internal and externally delivered training courses, and the angst this causes the participants. He works with the field team on shareholders' properties where he believes he can add value to their business through the best use of our products and services and finally he joyously spends a considerable amount of time representing both scientific and farmer interests in resource management hearings and in the dealings with regional councils and industry groups.

Agriculture is the driving force of this nation's economy, and as such it is important for every person living in New Zealand. He enjoys working with the down to earth and pragmatic stewards of the land. Besides, he has somewhat latterly worked out that the biggest reservoir of feral deer and pigs is accessible on the shareholders farms and he often tries to wheedle his way into an invitation to hunt on their properties!

Is Disruption the New Black? A Luddite's View.

What would Norman Taylor, a soil science pioneer and visionary in earlier days, think of the current challenges we have in agriculture? There are many e.g., water quality and quantity, climate change, soil erosion and contamination, none of which are simple issues to deal with anymore, but tackle them we must or Gaia is in trouble! Disruption is a word frequently over used in the media and by thought leaders today, and not only in agriculture. It is often used in a negative or threatening sense but disruption has happened often in world agriculture through the ages and it still survives and feeds most of the burgeoning world population.

There are a myriad new technologies with potential to revolutionise aspects of our current system of agriculture but are they all as good as they are made out to be in terms of practicality, human nutrition and environmental consequence? Are there any new frontiers in terms of soil research and practice which may help agricultural production systems move forward? Let's discuss all these questions and more in this address.

PLENARY SPEAKERS

Greg Hart

Mangarara Station

Talk Time: Wednesday 5 December 9:10am

Greg Hart grew up on a family farm near Methven, Mid-Canterbury. After gaining a Bachelor of Agriculture from Massey University and working in the agriculture industry, he and his wife Rachel worked in partnership with Greg's parents to develop Mangarara Station in Hawke's Bay. After the birth of their first child, Greg and Rachel began thinking about the world they would leave their children.

Greg is now committed to being part of the positive change taking place in the world to bring us back within the boundaries nature sets for us. He is transitioning the traditional sheep and cattle station to a farm of the future that creates balance by developing diverse, integrated, regenerative farming systems, restoring ecosystems through tree planting, sequestering carbon from the atmosphere and building healthy soil using holistic grazing techniques as a solution to climate change, and opening the farm to the public to enable others to reconnect to the earth that sustains us. The ethos for the farm is "Optimising Life"

Mangarara – A New Narrative for The Family Farm

I am writing this abstract a week after the IPCC landmark report that states global warming should not exceed 1.5C and therefore carbon emissions' must reduce by 60% from (2015 levels) within 12 years and be reduced to zero by 2050. Rather than reacting based on fear I focus on the opportunity to reimagine a world that honours all life and gives us the chance to evolve our understanding of what it means to be human, and how we apply this to The Family Farm.

A long, ongoing journey of learning has lead us to a farming system known as Regenerative Agriculture. This is a system of principles and practices that increases biodiversity, enriches soils, improves watersheds, and enhances ecosystem services. By capturing carbon in soil and aboveground biomass, Regenerative Agriculture aims to reverse global climate change. At the same time, it offers increased yields, resilience to climate instability, and higher health and vitality for farming communities. The system draws from decades of scientific and applied research by the global communities of organic farming, agroecology, holistic grazing, and agroforestry. We will look at our experience and how we are applying these principles at Mangarara.

PLENARY SPEAKERS

Dr Estelle Dominati
Research Scientist, AgResearch
Talk Time: Wednesday 5 December 9:50am

Dr Estelle Dominati is originally from France. She has a Master's degree in Agronomy and sustainable agriculture from SupAgro in Montpellier (France, 2006). She completed her Ph.D. in Ecological Economics with Massey University in Palmerston North and AgResearch in 2012 on valuing soil natural capital.
She has been working for AgResearch since May 2011 as a research scientist.
Her early research addressed the addition of a soil/land component to natural capital and ecosystem services frameworks as well as economic valuation of ecosystems services from agro-ecosystems.
More recently, her research has been focusing on taking an ecosystems approach to resource management and the sustainability of agro-ecosystems and more specifically on using ecosystem-based management to look at whole farm system analysis and optimisation within environmental and cultural boundaries.
In the last 3 years, she has been working closely with Māori agri-businesses on the alignment of Mātauranga Māori and the ecosystems approach to look at holistic farm planning.

Using land information and the Ecosystem Approach for farm planning and system design

The last 20 years have seen remarkable progress in recognising the value of soils beyond their agronomic value towards characterising their role in sustaining healthy ecosystems and thereby economies and societies.
To capture the recognition of the central role soils play in sustaining the provision of all ecosystem services, land evaluation and farm planning need to re-invent themselves in order to enable the quantification of all benefits obtained from farm landscapes.
Here we explore how several disciplines, including Mātauranga Māori, can be brought together to advance land evaluation and assist in designing farm systems that are not only sustainable and operate within environmental boundaries but also performant as businesses and provide cultural and social benefits to society.
Land evaluation has a long history of describing and quantifying the productive capacity of soils. However there is a need for this discipline to evolve and recognise all services provided by landscapes as well impacts on receiving environments.
Ecological theory informs the relationship between stocks and processes and supports the premise that the manipulation of key stock attributes changes ecosystem function and service provision.
Te Ao Māori is a holistic worldview linking all components of natural environments together with people. This has strong similarities with the Ecosystem Approach.
Finally, farm planning, which focuses more on socio-economic constraints to the production system, is the tool enabling strategic planning at the farm scale.
We suggest that the combination of these disciplines enables more of the interactions between natural capital, which includes soils, vegetation and waterways, built capital and people, to be investigated.
We will demonstrate through a series of examples how the use of next generation farm plans based on Mātauranga Māori and the Ecosystem Approach and new modelling analytical capabilities can help bring together business, environment and cultural goals while focusing on farm performance.

PLENARY SPEAKERS

Sam Robinson

Farmer

Talk Time: Wednesday 5 December 3:30pm

Mr Sam Robinson is a hill country farmer from Central Hawke's Bay. Sam brings strong governance experience in New Zealand agribusiness and extensive red meat industry expertise to Silver Fern Farms. He is currently an independent director of NZ Young Farmers and is the past Chairman of AgResearch and Richmond Ltd, as well as a past director Port of Napier, Farmlands, AgMardt and AsureQuality.

Resource management challenges in today's era

The presentation will comment on NZ society's changing attitude to the use and development of natural resources for economic benefits.

It will argue that there is an important need to involve science and scientists in policy development, management and monitoring.

NZ society needs to regain its understanding of science and respect for scientists, including where they can contribute to Resource Management policy.

PLENARY SPEAKERS

Jonno Rau

Pedologist, Manaaki Whenua - Landcare Research

Talk Time: Wednesday 5 December 3:50pm

Jonno is a pedologist with Manaaki Whenua - Landcare Research based in Hamilton, New Zealand. After traveling the globe working as a rafting guide in locations including Japan, Norway and Switzerland I returned to New Zealand and found work in the film industry working on films including The Hobbit. Jonno has completed a BSc and will soon complete a MSc from the University of Waikato.

My Masters project evaluated the soil, climate and topography of the Wairoa District to identify potential opportunities for horticultural development. The climate was characterised by creating local scale chilling hour, growing degree day and spring frost risk climate maps which were used to help evaluate potential land use change. In addition, representative soils were sampled to determine their soil moisture retention capacity. The soil water holding capacity data with 10yrs of daily rainfall and evapotranspiration were then used within a soil water balance model to estimate seasonal irrigation quantities for a range of crops.

When not working with Manaaki Whenua - Landcare Research Jonno can be found rock-climbing or kayaking.

Maintaining and improving the value of Māori land: Case study from Wairoa District

Traditional Māori beliefs influence the way Māori view and manage land. When Ranginui separated from Papa-tū-ā-nuku multiple responsibilities were given to Māori to help sustain the well-being of people, their communities and the natural resources at hand.

The Wairoa District, on the East Coast of the North Island of New Zealand as at 2013 had Māori owned land totalling 47,020 Ha (11.4% of the District) of which 4,663 Ha is in Land Use Capability classes 1-3. Much of the Māori owned land is underdeveloped with less than 1 Ha in horticultural land use.

As at 2013 58.6% of the Wairoa District population identified themselves as Māori. Since 1991 the District's population has steadily fallen which can be attributed toward the lack of job and career opportunities. The objective of the study was to provide information to help inform landowners (including Māori) who may wish to invest in horticulture which could improve the economic situation of the District.

Field work involving local scale climate mapping and soil characterisation of areas with potential for horticulture in Wairoa District was completed in 2017. Constructed climate and topographical maps with existing soil maps were evaluated against known crop growth requirements to produce crop potential maps identifying areas with potential for crop production. Horticultural crops included in this study include kiwifruit, apples, cherries.

Between mid-April – 31 October 2017, 45 portable iButton temperature loggers were deployed throughout Land Use Capability classes 1-3 in the Wairoa District and were set to record hourly temperature. When regressed against nearby climate stations, long term (18 -26 years) temperature datasets were derived from the short term iButton datasets. From the long-term datasets local scale chill hour, growing degree days and October frost risk maps were constructed for the Wairoa District.

The crop potential maps can enhance a land owner's ability to make informed decisions resulting in economic benefits to whanau, community and the Wairoa District.

PLENARY SPEAKERS

Blair Waipara

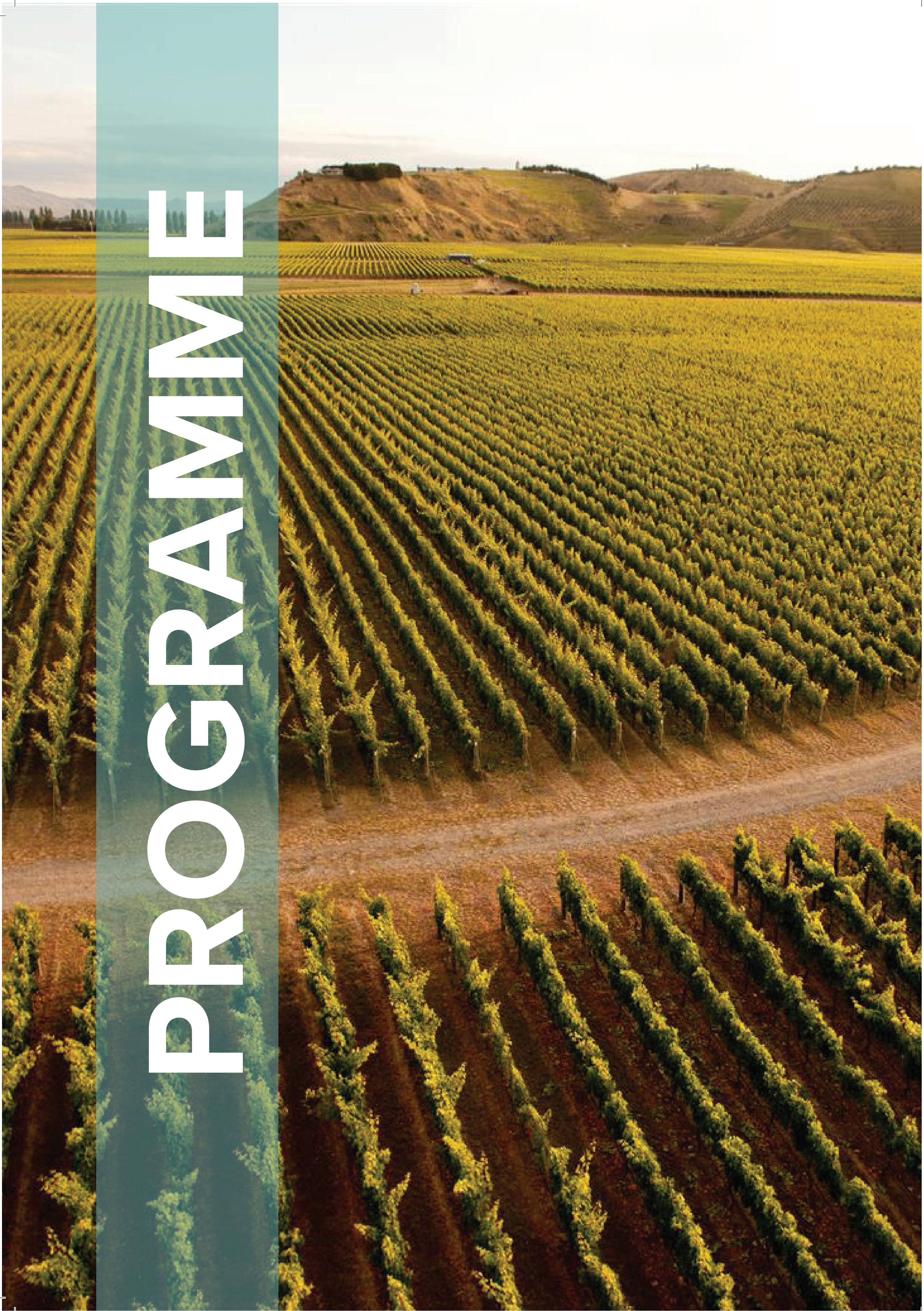
Land Development Manager, Te Tumu Paeroa

Talk Time: Wednesday 5 December 4:10pm

Blair is the Land Development Manager for Te Tumu Paeroa. He manages a team of professionals who are passionate and focused on working with Maori land owners to develop and improve existing land based businesses. He manages a portfolio of high performing primary industry businesses including the 2014 Ahuwhenua Maori Dairy Farm of the Year and the award winning Hamama Kiwifruit Orchard in the Bay of Plenty. His team also has a strong focus on new enterprise development having direct experience in working with land owners to build new agricultural and horticultural businesses across a range of industries. The team is currently leading a major multi-million dollar kiwifruit orchard development programme in the Bay of Plenty which is looking to develop 10 orchards in the next 24 months. Blair is of Rongowhakaata descent.

Taikura Nuku – Te Tumu Paeroa's common operating platform for the potential of Maori Land

Te Tumu Paeroa, through years of working and engaging directly with Maori Land owners, have created a new approach to the identification of land potential – known as Taikura Nuku. We'd love to share this exciting development and demonstrate how we are using this new approach in working with Maori Land owners to drive current and future land use decisions that are enduring.


PROGRAMME

DAY ONE: MONDAY 3 DECEMBER			
8:30	Registration Desk Opens (Napier Conference Centre Foyer)		
10:00	Mihi/Powhiri Welcome – James Palmer HBRC Housekeeping (Main Plenary Room - Walker Room)		
10:30	MORNING TEA BREAK		
Location	**Walker Room – Chair: Rebecca Withnall**		
11:00	Keynote Speaker: Annabel Langbein, A*uthor, Publisher and Celebrity Cook* Soil Matters		
11:45	Keynote Speaker: Andrew Waterhouse, UCDavis and Mark Shepherd, *AgResearch* The science behind 'Terroir'		
12:30	LUNCH		
Location	**Walker Room**	**McCraw Room**	**Pollok Room**
Session	**Our Land and Water National Science Challenge** Kindly sponsored by Our Land and Water - National Science Challenge AgResearch	**Soil Carbon**	**Soil contamination, degradation and remediation**
Chair	Rich McDowell	Karin Muller	Trish Fraser
1:30	Richard McDowell *Our Land and Water National Science Challenge* A strategy for optimising catchment management actions to improve water quality	Paul Mudge *Manaaki Whenua - Landcare Research* Impact of irrigation on soil carbon and nitrogen stocks	*Mahdiyeh Salmanzadeh *Wintec and Waikato University* Source-tracking cadmium in New Zealand agricultural soils: a stable isotope approach
1:45	Ross Monaghan *AgResearch* Mitigating the impacts of pastoral livestock farming on water quality: what have we achieved?	Scott Graham *Manaaki Whenua - Landcare Research* Carbon and nitrogen balances for irrigated and non-irrigated lucerne: insights to minimise losses.	*Jesus Adalberto Jimenez Torres *Massey University* Adsorption-desorption of glyphosate in New Zealand soils
2:00	Linda Lilburne *Manaaki Whenua - Landcare Research* The land use suitability concept: A Southland case study	*Carmen Rosa Medina Carmona *Lincoln University and Plant & Food Research* Irrigation of temperate pastures does not increase the net soil C inputs via photosynthesis	*Zicheng Yi *Lincoln University* The bioavailability of cadmium in New Zealand cropping soils
2:15	Alan Renwick *Lincoln University* Land use transformation; can science de-risk barriers to land use change?	*Jonathan Nuñez *Manaaki whenua - Landcare Research* Does reduced soil carbon accessibility to microbial decomposition decrease nitrogen losses?	Jo Cavanagh *Manaaki-whenua Landcare Research* Influence of soil properties on the uptake of cadmium in selected agricultural crops
2:30	Neha Jha *Massey University* Molecular approaches to identify benign denitrification in shallow groundwaters	Roberto Calvelo Pereira *Massey University* Assessment of soil organic matter stratification in two pastoral soils following full inversion tillage-renewal	*Dharshika Welikala *Lincoln University* Cadmium sorption and mobilization by organic soil amendments
2:45	*Marcela Gonzalez *Massey University* Dissolved gasses as indicator of denitrification process in shallow groundwater in agricultural landscape	Denis Curtin *Plant & Food Research* Empirical evidence for the existence of labile and passive soil organic matter pools	*Thangavelautham Geretharan *Massey University* Effect of Fluorine on Rhizobia growth and morphology

3:00	AFTERNOON TEA BREAK		
Location	**Walker Room**	**McCraw Room**	**Pollok Room**
Session	**Our Land and Water National Science Challenge *Continued***	**Soil Carbon *Continued***	**Soils in the landscape (Pedology) – Past, Present and Future**
Chair	Reece Hill	Paul Mudge	Jo Cavanagh
3:30	Gina Lucci *AgResearch* The impacts of delivering credence attributes of livestock products	Carolyn Hedley *Manaaki Whenua - Landcare Research* Development of a soil carbon monitoring framework and its implementation in hill country	*Nilusha Ubeynarayana *Massey University* Innovative cadmium (Cd) electrode to quantify soil and plant Cd species
3:45	Lisa Pearson *Land and Water Science* Physiographic Environments of New Zealand: An integrated landscape classification for understanding variation in water quality	Alec Mackay *AgResearch* Changes in soil carbon in hill country under contrasting phosphorus fertiliser and sheep stocking rate	Nathan Odgers *Manaaki Whenua - Landcare Research* Soilscapes for understanding regional soil distributions
4:00	Stewart Ledgard *AgResearch* Adaptation of water eutrophication indicators for European Product Environmental Footprinting of New Zealand products	Miko Kirschbaum *Landcare Research - Manaaki Whenua* Are soil carbon stocks controlled by a soil's capacity to protect carbon from decomposition?	Alan Palmer *Massey University* The role of tephra cover in slope stabilisation following the Last Glacial in Waipaoa Catchment.
4:15	Our Land and Water discussion on research requirements on the future use of versatile soils	Roberta Gentile *Plant & Food Research* Comparing deep soil carbon stocks under kiwifruit and pasture land use	*Carol Smith* *Lincoln University* Project-based learning and soil judging: approaches to teaching the "hidden skills" in Soil Science.
4:30		Sam McNally *Plant & Food Research* Vertical distribution of soil carbon following full inversion tillage: implications for C sequestration	*Sunita Lata *CQ University* Hydropedology and salinity in Hedlow Creek Catchment
4:45pm	NZSSS AGM (Walker Room)		
5:30 - 7.30	**BBQ Function at the Napier Conference Centre** kindly sponsored by Ravensdown		

DAY TWO: TUESDAY 4 DECEMBER Field Trips			
7:30	Registration Desk Open (Napier Conference Centre)		
Field Trip	**Productive landscapes on the plains** **Kindly sponsored by FAR**	**Spectacular Soils** **Kindly sponsored by OLYMPUS AUSTRALIA**	**Regenerative farming-what is it? And the influence soils on wine making (Terroir)** **Kindly sponsored by Hill Laboratories**
Departure	8.00am Napier Conference Centre	8.00am Napier Conference Centre	8.00am Napier Conference Centre
	First stop: A mixed cropping/grazing enterprise in Otane owned and operated by Hugh and Sharon Ritchie. **Lunch stop:** The Pekapeka wetlands for lunch and a walk. **Final Stops:** True Earth Organics which is situated near Bridge Pa and several renowned wineries on the Gimblett Gravels. Our fourth and final stop will be the Chantal Organics located in Napier where David Alexander (Business Improvement Manager) will be giving us an overview of the business and a tour of the processing facility.	**Stops:** Te Mata Peak summit. We will travel across the alluvial plains and the low rainfall loess covered downlands through the huge ash-covered, tilted slabs of Neogene sandstone, limestone and conglomerate, up to the pumice and greywacke of the Kaweka Range.	**First stop:** Mangarara station owned and run by Greg and Rachael Hart. **Second stop:** Te Awa winery located on the famous wine growing area of the Gimblett Gravels where Jonathan Hamlet, Chief Viticulturist for Villa Maria in Hawke's Bay will meet us.
Return	5.00pm at Napier Conference Centre	5.30pm at Napier Conference Centre Following the field trip, attendees are invited to an optional informal dinner at the Emporium.	5.00pm at Napier Conference Centre
	Student Function kindly sponsored by Plant & Food Research **Par2 MiniGolf 6:00 – 7:00pm** **From 7:00pm Drinks and Nibbles at Monica Loves Bar**		

DAY THREE: WEDNESDAY 5 DECEMBER *WORLD SOILS DAY*			
Location	**Walker Room – Chair: Paul Johnstone**		
8:30	Keynote Speaker: Brent Clothier, *Plant & Food Research* Soil, Carbon, and Water: Natural Capital Delivering Valuable Ecosystem Services		
9:10	Plenary Speaker: Greg & Rachel Hart, *Mangarara Station* Mangarara - The Family Farm, Regenerative Agriculture and why every bite counts		
9:50	Plenary Speaker: Estelle Dominati, *AgResearch* Using land information and the Ecosystem Approach for farm planning and system design		
10:10	MORNING TEA BREAK		
Location	**Walker Room**	**McCraw Room**	**Pollok Room**
Session	**Quantifying and mitigating nutrient losses to water**	**Greenhouse Gases**	**Soil fertility, nutrient management and plant nutrition**
Chair	James Hanly	Tim Clough	Haydon Jones
10.45	*Grace Chibuike *Massey University* Assessment of the nitrate attenuation capacity of a seepage wetland in a hill country landscape	*Kamal P. Adhikari *Massey University* Effectiveness and longevity of 2-NPT and nBTPT in reducing NH_3 emissions from cattle urine-patches	Moira Dexter *AgResearch* Using laboratory soil incubations to study the nitrogen cycle
11:00	Juergen Esperschuetz *University of Canterbury* Effect of different wood chip material on nitrogen leaching from stand-off pads	Jiafa Luo *AgResearch* Nitrous oxide emissions from beef and dairy cattle excreta deposited on grazed pastoral hill lands	Peter Beets *Scion* Soil productivity drivers in New Zealand planted forests
11:15	Selva Selvarajah *Enviroknowledge* Can organic farming reduce nitrate leaching in polluted and sensitive catchments? A critical review	Sergio Morales *University of Otago* Urine patches: unique ecosystems that reshape soil microbiomes and N cycling rules	Niklas Lehto *Lincoln University* White lupin roots forage and mobilize phosphorus in a nutrient-poor soil
11.30	Matthew Norris *Plant & Food Research* Measuring losses of N and P from cropping systems using a network of drainage fluxmeters	*Anne Wecking *University of Waikato* Bottom-up or top-down? Paddock-scale nitrous oxide budgets using static chamber and eddy covariance data	*Rohit Lal *Massey University* Sustainable nutrient management system for taro growers in Taveuni, Fiji
11.45	*Brian Levine *Massey University* Quantifying nutrient attenuation performance of Detainment Bunds in the Lake Rotorua Catchment: Preliminary data	*Camille Rousset *Lincoln University* Relative Gas Diffusivity; an integrative tool for estimating N_2O emissions from soils?	Bert Quin *Quin Environmentals (NZ) Ltd* RPR Revisited 5: A wider perspective on potential reductions in all forms of P loss
12:00	LUNCH		Soils Portal Lunchtime Quiz Breakout Room 2 (downstairs)

Location	Walker Room	McCraw Room	Pollok Room
Session	**Quantifying and mitigating contaminant losses to water *Continued***	**Greenhouse Gases - *Continued***	**Soil fertility, nutrient management and plant nutrition - *Continued***
Chair	Jack Pronger	Carolyn Hedley	Matt Norris
1:00	Maria Jesus Gutierrez Gines *The Institute of Environmental Science and Research Ltd.* 30 years of effluent land-application	Amanda Matson *Scion* Soil and tree-stem N_2O fluxes of a large-scale oil palm plantation in Sumatra, Indonesia	*Tom Meaclem *University of Canterbury* Effect of temperature variations on Controlled Release Fertiliser applications and modelling
1:15	Dave Houlbrooke *AgResearch* Contaminant losses from contrasting peat soil types and farm dairy effluent regimes: a lysimeter study	Sally Price *Lincoln University* Optimising soil conditions for methane oxidation - using land use change as an example	Jeff Reid *Plant & Food Research* Nutrient Management for Vegetable Crops in NZ – a major update for the industry
1:30	Jianming Xue *Scion* Beneficial use of biosolids to forestland: What are the environmental impacts?	*Jimena Rodriguez *Massey University* Does plantain sward affect N_2O emissions during different seasons?	Adrian Hunt *Plant & Food Research* Soil sampling strategy on system outcomes in maize: A case study
1:45	Brendon Malcolm *Plant & Food Research* Using catch crops to mitigate nitrate leaching following autumn grazed fodder beet in Waikato.	**Soil Physics and Water Management** Benye Xi *Beijing Forestry University, China* Effects of different irrigation regimes on growth and water use efficiency in *Populus tomentosa* plantations	Simeon Smaill *Scion* Optimising forest productivity, soil nutrient pools and environmental outcomes with NuBalM
2:00	Wei Hu *Plant & Food Research* No-tillage to reduce compaction effect on soil physical quality, nitrogen loss and barley productivity	Jun Yi *Central China Normal University* Characterising of macropores and preferential flow of mountainous forest soils with difference human disturbance intensities	*Akinson Tumbure *Massey University* Using recycled glass to increase P availability of insoluble Dorowa phosphate rock
2:15	Diana Selbie *AgResearch* Progress towards quantifying some environmental implications of New Zealand dairy sheep systems		Adrian Hunt *Plant & Food Research* Considering the value proposition of variable rate N
2:30	AFTERNOON TEA BREAK & **POSTER SESSION** kindly sponsored by ASPAC		
Location	**Walker Room – Chair: Megan Balks**		
3:15	Plenary Speaker: Sam Robinson, *Farmer* Resource management challenges in today's era		
3:35	Plenary Speaker: Jonno Rau, *Landcare / Manaaki Whenua* Maintaining and improving value of Maori land		
3:55 - **4:15**	Plenary Speaker: Blair Waipara, *Te Tumu Paeroa* Taikura Nuku – Te Tumu Paeroa's common operating platform for the potential of Maori Land		
	CONFERENCE DINNER kindly sponsored by Ballance Agri-Nutrients Venue: Mission Estate Winery		
6:00	Buses Depart Napier Conference Centre		
6:30	Pre-Dinner Drinks / Dinner starts at 7:00pm		
From 10:30	1st Bus Returns and last bus at midnight		

DAY FOUR: THURSDAY 6 DECEMEBER			
Location	**Walker Room**	**McCraw Room**	**Pollok Room**
Session	**Soil physics and water management**	**Soil Carbon 2**	**Soil quality and function**
Chair	Sam McNally	Dirk Wallace	Peter Almond
9:00	Michael Blaschek *Manaaki Whenua - Landcare Research* Prediction of soil available water-holding capacity from visible near-infrared reflectance spectra	*Yuan Li *Lincoln University* Root exudates enhance soil respiration rates and the ratios of N_2/N_2O emissions	Mike Beare *Lincoln University, Plant & Food Research* Recent advances in testing and predicting N mineralisation in agriculture soils of New Zealand
9:15	Sam Carrick *Manaaki Whenua* SWAMP3: The S-map soil water characterisation initiative	Matteo Poggio *Manaaki Whenua - Landcare Research* Estimation of soil carbon stocks using a newly developed automated sensing platform	Karin Mueller *Plant & Food Research* X-ray CT and gas transport-derived pore-network characteristics of a silt loam soil
9:30	Steven Dellow *Plant & Food Research* Is the ridge and furrow bed architecture limiting potato production?	*Jasmine Robinson *The University of Waikato* Partitioning the temperature dependence of microbial respiration from root inputs and soil organic matter.	Erin Lawrence-Smith *Plant & Food Research* Application of soil C stabilisation capacity methodology for soil quality monitoring
9:45	John Drewry *Manaaki Whenua - Landcare Research* Temporal changes in soil physical properties under irrigated cropping	Aaron Wall *University of Waikato* Does imported supplemental feed to a dairy farm result in an increase in soil carbon?	Gabriel Moinet *Manaaki Whenua Landcare Research* Out with chemical recalcitrance: field evidence that soil organic matter persistence is an ecosystem property
10:00	MORNING TEA BREAK		
10:30	Keynote Speaker: Simon Upton, Parliamentary Commissioner for the Environment Chair: Diana Selbie		
Session	**Soil physics and water management *Continued***	**Soil biology and ecosystems**	**Macro Influences**
Chair	Sam Carrick	Roberta Gentile	Erin Lawrence-Smith
11:15	*Mr Ahmed El-Naggar *Massey University* Soil and crop sensing technologies informing best application of irrigation water	Sarah Addison *Scion* Decade effects of forest ecosystem management on soil biodiversity and function	*Annette Carshalton *University of Waikato* Soil climate and active layer depth monitoring, Ross Sea Region, Antarctica
11:30	Steve Green *Plant & Food Research* Measuring runoff from a kiwifruit orchard in the Bay of Plenty	Sofie De Meyer *Maldiid Pty Ltd* RHIZO-ID as a novel technology for direct rhizobia identification	Haydon Jones *Waikato Regional Council* Loss of versatile land available for production
11:45	Rogerio Cichota *AgResearch* Understanding the spatial distribution of treading damage risk across farmlands	*Stanislav Garbuz *Massey University, School of Agriculture & Environment* Effect of biochar on plant growth, soil biology and biochemistry in a 6-month mesocosm experiment	Reece Hill *Waikato Regional Council* Local scale land fragmentation on high class soils in the Waikato region
12:00	Priscilla Lad *Scion* Quantifying soil microsite effect in forest soils with electromagnetic induction	Michelle Peterson *Plant & Food Research* Soil microbial community structure and function is influenced by plant secondary metabolites excreted in urine	Carlo van den Dijssel *Plant & Food Research* Plant-based protein: A sustainable protein source meeting future opportunities?

Location	Walker Room	McCraw Room	Pollok Room
12:15	*Alexandre Michel *Plant & Food Research* Accurate scheduling of irrigation using plant-based measurements	Robert Simpson *Plant & Food Research* The Tea Bag Index and Soil Carbon Cycling	Mark Shepherd *AgResearch* Reflections on the implications of the 'Digital Age' on delivery of solutions for NZ farming
12:30	LUNCH		
Session	**Soil physics and water management *Continued***	**Soils in the landscape (Pedology) – Past, Present and Future**	**Macro Influences *Continued***
Chair	Gina Lucci	Carol Smith	Erin Lawrence-Smith
1:15	Veronica Penny *Manaaki Whenua Landcare Research* Changes in soil under irrigation: a summary of research findings	Peter Almond *Lincoln University* Retaining soils as a landscape phenomenon in the digital era	Pierre Roudier *Manaaki Whenua Landcare Research* Efforts towards a national scale, fine resolution grid of soil pH
1:30	Jack Pronger *Manaaki Whenua - Landcare Research* A simple tool for estimating water use efficiency in irrigated and non-irrigated fodder crops	Thomas Caspari *Manaaki Whenua - Landcare* Research Revitalising the National Soils Database	Rogerio Cichota *Plant & Food Research* A new landscape-scale framework to analyse crop responses to climates and soils across New Zealand
1:45	Aldrin Rivas *Lincoln Agritech Ltd*. Can we defensibly estimate catchment-scale flowpaths contributions based on widely available geospatial data?	Scott Fraser *Manaaki Whenua Landcare Research* Developing tools that build understanding of soils in the landscape	Barry Lynch *Hawke's Bay Regional Council* Using the SedNetNZ model as a policy planning tool in Hawke's Bay
2:00	*Balin Robertson *Lincoln University* Water retention properties of stony soils	Sharn Hainsworth *Manaaki Whenua - Landcare Research* Bringing the geomorphology back to modern NZ soil survey: the old "soil unit"	Andrew Hammond *CQ University Australia* Hydropedology and soil-landscapes of North Curtis Island marine plain, Central Queensland, Australia
2:15	Dirk Wallace *Plant & Food Research* Amendment incorporation to increase soil water retention of shallow stony soils	Gerard Grealish *Manaaki Whenua - Landcare Research* Farm-scale soil mapping protocols for New Zealand	
2:30	AFTERNOON TEA BREAK		
Location	**Walker Room**		
2:45	Norman Taylor Memorial Lecture – Ants Roberts, Ravensdown Is Disruption the New Black? A Luddite's View Chair: David Houlbrooke		
3:30-3:50	Conference Closing		

POSTER LIST

Presenting Author	Organisation	Poster #	Paper Title	Theme
Craig Anderson	Plant & Food Research	1	Can soil carbon extracts be used to culture subsamples of soil microbiota for mini-metagenomics?	Soil biology and ecosystems
Nathan Arnold	Plant & Food Research	2	Catch crops reduce the risk of nitrogen leaching after summer cropping in the Waikato	
Mike Beare	Plant & Food Research	3	Effects of placement and application rate on retention of crop residue carbon and nitrogen	Soil carbon and greenhouse gases
Sam Carrick	Manaaki Whenua	4	Facilitating collaborative research through the New Zealand – China Water Research Centre	Macro Influences – Global Food, Water Scarcity, Regulatory Requirements, Climate Change, The Digital Age
Tim Clough	Lincoln University	5	Soil matric potential effects on soil oxygen, redox, N2O production and isotopic composition.	Soil carbon and greenhouse gases
Thomas Corbett	The University of Waikato	6	Surface-water nutrient quantification and the linkages to land-use: enhancement of ‘diffusive gradients in thin-films’ methodology	Sustainable management – paddock to catchment scales
Kirstin Ella Deuss	Lincoln University	7	The influence of artificial subsurface drainage on soil hydraulic properties	Soil physics and water management
Yeganeh Eslami	Scion	8	Biological nitrification inhibition activity of New Zealand native and introduced plant species.	Soil biology and ecosystems
Bhupinder. Pal Singh	NSW Department of Primary Industries, Australia	9	Impact of integrated wheat residue and nutrient management on soil carbon pools and microbial-use efficiency	Soil carbon and greenhouse gases
Xiaoli Fu	Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences	10	Elaborate differences between trees and understory plants in the deployment of fine roots	Soil biology and ecosystems
Steve Green	Plant & Food Research	11	Water use efficiency of vegetable crops in the United Arab Emirates	Macro Influences – Global Food, Water Scarcity, Regulatory Requirements, Climate Change, The Digital Age
Belinda Hackney	NSW Department Of Primary Industries	12	Soil and microclimate impact predicted and actual permanent pasture productivity	Sustainable management – paddock to catchment scales

Presenting Author	Organisation	Poster #	Paper Title	Theme
James Hanly	Massey University	13	Reducing nitrate leaching risk from a pasture soil by increasing dairy cow urine patch size	Soil fertility, nutrient management and plant nutrition
Trevor Hendry	Lincoln University	14	A new suction cup and lysimeter array (SCALAR) system to measure leaching losses	Soil physics and water management
Reece Hill	Waikato Regional Council	15	Changes in drained peatland extent for the Lake Poukawa catchment, Hawke's Bay	Soils in the landscape (Pedology) – Past, Present and Future
Jay Howes	PGG Wrightson	16	A comparison of four methods for assessing treading damage	Soil physics and water management
Amanda Judge	AgResearch	17	Pasture production response to zeolite incorporation in a pumice soil	Soil fertility, nutrient management and plant nutrition
Chao Kong	Massey University	18	Formulating Technosols to Reduce Salinity and Water Stress of Crops Growing under Aridic Conditions	Soil physics and water management
Andrea Leptin	Lincoln University	19	Biological nitrification inhibition in forage crop rhizosphere soils	Soil fertility, nutrient management and plant nutrition
Yang Li	Lincoln University	20	Influence of lime, phosphate and fluoride applications on the water extractable-organic carbon of Allophanic soil	Soil carbon and greenhouse gases
C Lizarralde	Lincoln University	21	Estimating phosphorus losses in surface runoff and subsurface flow from soils receiving dairy factory wastewater	Use of soils for wastewater/effluent treatment
Alec Mackay	AgResearch Ltd	22	Earthworm abundance influences soil ecosystem services provision	Soil biology and ecosystems
Khadija Malik	Massey University	23	Impact of manipulating dietary crude protein intake on partially housed dairy cows on NH3 emissions	Soil carbon and greenhouse gases
Amanda Matson	Scion	24	Nitrogen movement after urea application to a young Pinus radiata forest on pumice soil	Soil fertility, nutrient management and plant nutrition
Ian McIvor	Plant & Food Research	25	Tree willow root growth in sediments varying in texture	Natural capital and ecosystem services
Dean Meason	Scion	26	Using remote sensing to quantify soil moisture dynamics in New Zealand's commercial forest estate	Soils in the landscape (Pedology) – Past, Present and Future
Jamie Millar	University of Waikato	27	Decreases in soil C and N under irrigation of Pumice Soils	Soil carbon and greenhouse gases
Parsa Mohajeri	Lincoln University	28	"Nitrate and Phosphorous Removal by Novel Couple Bottom Aeration (CBA) Method:Optimization by Response Surface Methodology "	Use of soils for wastewater/effluent treatment

Presenting Author	Organisation	Poster #	Paper Title	Theme
Iván Ordóñez	Massey University	29	The effect of pasture species root traits on water uptake during water deficit	Soil physics and water management
Trish Fraser	Plant & Food Research	30	Soil nitrification inhibition by urine of sheep fed on plantain (Plantago lanceolata) is cultivar dependent	Soil biology and ecosystems
Michelle Peterson	Plant & Food Research	31	Soil microbial community structure and function is influenced by plant secondary metabolites excreted in urine	Soil biology and ecosystems
Andriy Podolyan	Lincoln University	32	Effect of plantain on the nitrification and abundance of ammonia oxidisers under a urine patch	Soil biology and ecosystems
Matteo Poggio	Manaaki Whenua - Landcare Research	33	Development of a mid infrared (MIR) spectral library for estimating properties of New Zealand soils	Soil quality and function
Weiwen Qiu	Plant & Food Research	34	Relationship between soil water content and organic matter mineralisation	Soil fertility, nutrient management and plant nutrition
Sephrah Rayner	Lincoln University	35	Plant growth and nitrogen uptake effects on isotopic composition of nitrate leached from pasture systems.	Soil fertility, nutrient management and plant nutrition
Aldrin Rivas	Lincoln Agritech Ltd.	36	Reducing nitrate discharges from artificial drainage with woodchip bioreactors	Sustainable management – paddock to catchment scales
Salome Seyedalikhani	Lincoln University	37	Effect of the biosolids application method on mānuka essential oil	Soil fertility, nutrient management and plant nutrition
Idri Siregar	School Of Agriculture And Environment - Massey University	38	Investigating the Effect of Rising Temperature on Carbon Pools and Fluxes in a Forest Thermo-Sequence in Taranaki	Soil carbon and greenhouse gases
Simeon Smaill	Scion	39	Working with soil natural capital to build better forests	Natural capital and ecosystem services
Christine Stark	Bioprotection Research Centre (Lincoln University)	40	Trichoderma application reduces toxic trace metals in kiwifruit orchard soils and improves overall plant health	Sustainable management – paddock to catchment scales
Matthew Taylor	Waikato Regional Council	41	Effects and subsequent recovery of agricultural land after salt water flooding	Soil physics and water management
Hendrik Venter	Ravensdown Fertiliser	42	Nutrient management trends observed from repeat Whole Farm Soil Testing results	Soil fertility, nutrient management and plant nutrition
Garrett Loretta	Scion	43	Integrating ‘biology’ into forest soil quality assessments	Soil biology and ecosystems
Steve Wakelin	Scion	44	Functional changes in microbial communities linked with low nitrate-N in soils	Soil fertility, nutrient management and plant nutrition
Anne Wecking	University of Waikato	45	Managing forest ecosystems in Mongolia - the crucial role of soil	Soil quality and function

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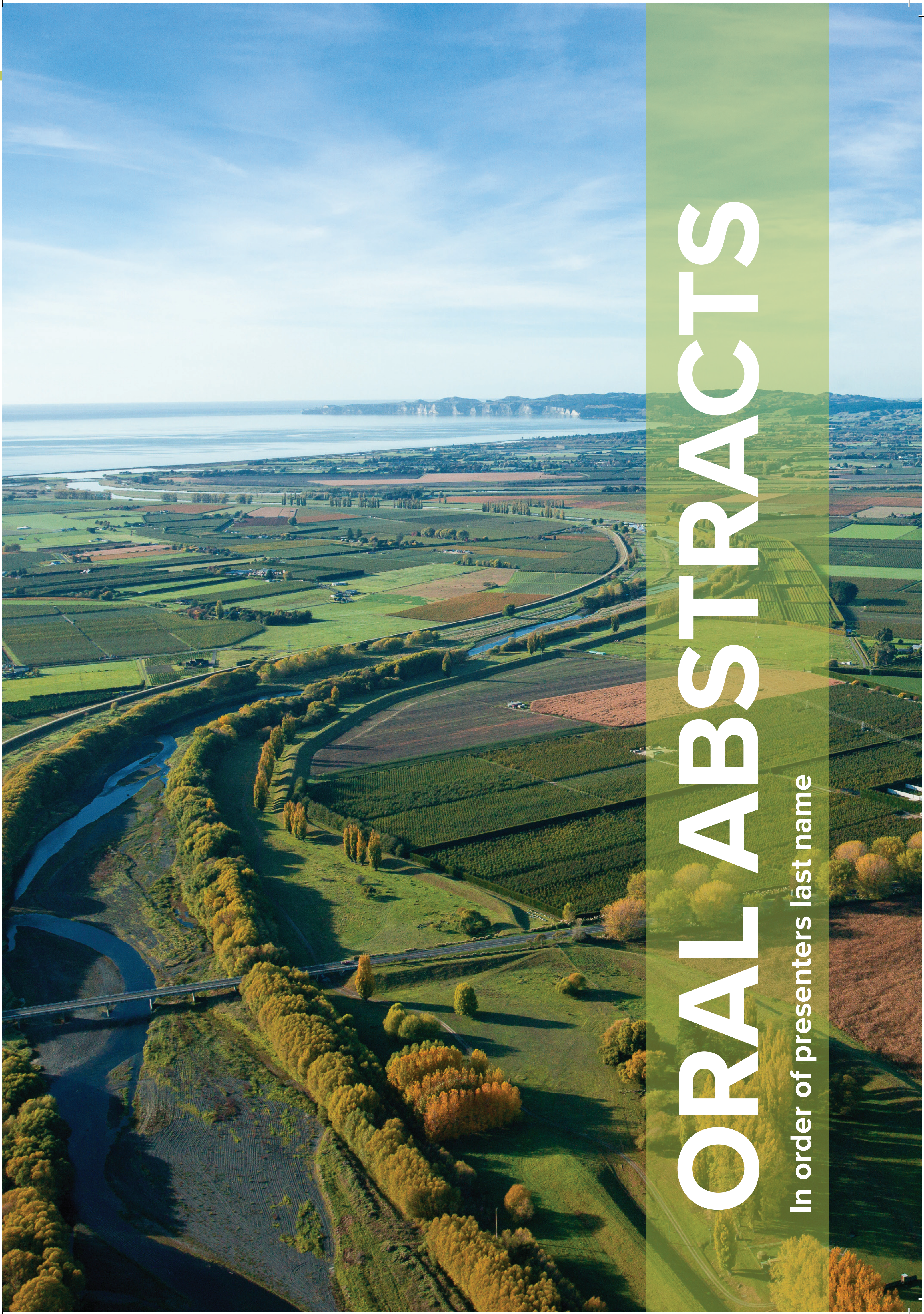
Brendon Welten	Agresearch	46	Effect of plantain on nitrogen transformations in a free-draining ash soil	Soil fertility, nutrient management and plant nutrition
Jianming Xue	Scion	47	Repeated application of biosolids improved soil fertility, pine growth and carbon sequestration on marginal land	Soil fertility, nutrient management and plant nutrition



ORAL ABSTRACTS

In order of presenters last name

Decade effects of forest ecosystem management on soil biodiversity and function

Sarah Addison[1], Simeon Smaill[2], Loretta Garrett[1], Steve Wakelin[2]
[1]Scion, Rotorua, New Zealand, [2]Scion, Christchurch, New Zealand

Effective management of soils is critical to establish and grow productive and sustainable planted Pinus radiata forest ecosystems. New Zealand planted forests have cropping rotations about every three decades which highlights the importance of understanding the long-term effects when evaluating sustainable forest management. This study used two long term trial sites from the Long-Term Soil Productivity Study (LTSP; end of second rotation) with the aim to uncouple the effects of planted forest site, harvest residue retention and fertiliser addition on soil ecosystems structure and function. The study used high throughput soil DNA sequencing of both the 16S rRNA and ITS rRNA genes, to determine the bacterial and fungal communities present. We were able to investigate the effects of forestry management practices (harvest residue retention and fertiliser addition) and relate soil edaphic properties with the soil microbial communities present. Our results provide strong evidence for an enduring (lasting more than two decades) impacts of forest management practices on microbial communities. The addition of fertiliser manifested in distinct changes of community structures for both bacteria and fungi. Fungal communities were significantly impacted by harvest residue retention, contrasting to bacterial communities that showed no evidence of impacts. Long-term, bacterial communities were resilient to change, whereas effects on fungal communities were enduring. The two sites had contrasting soil physicochemical properties, and significant differences in bacterial communities were present between sites due to these properties rather than any forest management practices. This highlights both the importance of investigating fungal and bacterial communities together with soil physicochemical properties and the value of long-term field-based studies. We conclude that while forestry management practices may improve the long term physicochemical conditions and tree growth, their impacts endure on the microbial population present in the soil and can have lasting effects.

Effectiveness and longevity of 2-NPT and nBTPT in reducing NH_3 emissions from cattle urine-patches

Kamal P. Adhikari[1], Surinder Saggar[1,2], James A. Hanly[1], Danilo F. Guinto[3]
[1]Massey University, Palmerston North, New Zealand, [2]Manaaki Whenua Landcare Research, Palmerston North , New Zealand, [3]Department of Primary Industry and Resources, Katherine, Australia

Ammonia (NH_3) emissions represent a loss of nitrogen from agricultural soils. The objective of this study was to compare the effectiveness and longevity of the urease inhibitor N-(2-Nitrophenyl) phosphoric triamide (2-NPT) with the more commonly used inhibitor N-(n-butyl) thiophosphoric triamide (nBTPT) in reducing NH_3 emissions from cattle urine patches. Two field experiments were conducted on a pasture site near Palmerston North. The first experiment started on the 23rd of November 2017 and the second experiment started on the 1st of May 2018. In the first experiment, the inhibitors nBTPT and 2-NPT were applied at the start of the experiment and urine was applied at 3 stages; a) 3 hours before, b) 28 days after, and c) 68 days after inhibitor application. In the second experiment, urine was only applied either 3 hours before or at the time of inhibitor application. In the first experiment, only 2-NPT significantly reduced total NH_3 emissions and only when urine was applied at stage (b). In the second experiment, both of the inhibitors significantly reduced total NH_3 emissions when urine was applied either 3 hours before or at the time of inhibitor application. The reduction was greater with 2-NPT compared to nBTPT when urine was applied at the same time as the inhibitors. Overall, 2-NPT showed a greater efficacy at reducing NH_3 emissions compared to nBTPT.

Retaining soils as a landscape phenomenon in the digital era

Peter Almond[1], Andre Eger[2], Philip Tonkin[3]
[1]*Lincoln University, Lincoln, ,* [2]*Manaaki Whenua - Landcare Research, Lincoln, ,* [3]*Retired, Christchurch,*

S-map, developed by Manaaki Whenua Landcare Research, has become the default platform by which legacy and new spatial soil information is disseminated. S-Map is a web-based digital spatial information system, which expresses soil variability via soil taxa rather than as individual soil attributes. Taxa are defined in a top-down hierarchical manner, based on the criteria of NZ Soil Classification down to 4th and 5th levels (family and siblings), and map units are necessarily defined solely according to their composition with respect to soil taxa. By contrast, earlier paper-based soil maps had more flexibility: taxonomic units (often soil series) were devised in a bottom-up way in sympathy with soil variability on the ground, and definitions of taxa optimised homogeneity of taxa with spatial contiguity of map units. Operationally, this meant that soil taxa and soil mapping units had strong associations with landforms. Accordingly, soil maps had a pedological legend showing how taxa related to classes of a soil classification system, and a physiographic legend showing how mapping units related to landform. Arising from such maps was colloquial understanding by farmers and other lay people of the landscape arrangement of soils, using familiar, geographically relevant soil names. While S-map adopts names of soil families from previous soil series, the top-down, strictly pedological nature of their definition means those soil families are no longer implicitly or explicitly associated with any particular landform, and moreover are no longer local; for example the Waimakariri family, which adopts the name of the Waimakariri series defined in Canterbury, is now mapped in the Wairarapa. The challenge in the new digital environment is finding a way to capture the fundamentally important relationship between soils and the landscape for cultural and scientific priorities. This paper is intended prompt a discussion on ways this could be achieved.

Soil productivity drivers in New Zealand planted forests

Peter Beets[1], Loretta Garrett[1], Amanda Matson[1], Mark Kimberley[1], Thomas Paul[1]
[1]*Scion, Rotorua, New Zealand*

Soil fertility is known to be one of a number of key drivers of forest productivity. However, our ability to determine the importance of soil fertility to Pinus radiata productivity has been limited by the lack of a nationally representative sampling framework. In New Zealand the national planted forest inventory plot network (part of the Land Use and Carbon Analysis System, LUCAS) was used to explore variation in a stand productivity index in relation to climate and soil factors. The stand productivity index used in this case is a measure of the mean annual increment in stem volume at age 30 years for stands growing at a final crop stocking of 300 trees per hectare (the “300 index”). Climate data (normalised average temperature and rainfall), solar radiation (corrected for slope and aspect using a digital terrain model), tree health scores, soil measures of fertility (including soil chemistry and categorical information such as soil type and land use history) were included in the analysis of variation in the 300 Index across the range of planted forest environments in New Zealand. Land that was previously managed for agricultural production resulted in a 20% gain in overall forest productivity, which is known as the “farm effect”. The soil chemistry data showed that the adjusted C/N ratio (an index of nitrogen fertility) and total phosphorus in the topsoil were the dominant drivers of productivity. The findings add to the knowledge of soil productivity drivers and further support site specific precision soil management.

Recent advances in testing and predicting N mineralisation in agriculture soils of New Zealand

Mike Beare[1], Denis Curtin[1], Kathryn Lehto[1], Craig Tregurtha[1], Weiwen Qiu[1], Rebekah Tregurtha[1], Richard Gillespie[1]
[1]*Plant & Food Research, Canterbury Agriculture and Science Centre, Lincoln, New Zealand*

Improved fertiliser management is critical to lifting the economic and environmental sustainability of agricultural production systems. Forecasting fertiliser N requirements depends on predicting the supply of plant-available N from soil and the demand for that N by crops/pastures during their growth. The nitrogen released by mineralisation of soil organic matter can contribute a large (but variable) amount of plant-available N. Accurately predicting the supply of N from mineralisation remains a key limitation to properly forecasting the amount and timing of fertiliser N additions.

Predicting the supply of plant-available N under field conditions requires knowledge of the soil's N mineralization potential (i.e. N released under "optimal" conditions) as well as capability to predicting how much of that N will actually be mineralised under varying environmental conditions (e.g. soil temperature and moisture). Soil type and management history affect the quality and quantity of soil organic matter that determines the amount of potentially mineralisable N (PMN). PMN is best measured using a longer-term aerobic incubation, but the procedure is laborious and time-consuming. A reliable, "laboratory-friendly" test for soil N mineralization potential is not available; this remains a major barrier to implementation of best management practices for N on farm.

This paper will describes recent advances in measuring PMN based on analysis of hot water extractable organic matter from a wide range of soils and land uses across New Zealand. We also describe preliminary results from a field validation trial that shows how PMN may be used to predict the supply of plant available N under field conditions.

Prediction of soil available water-holding capacity from visible near-infrared reflectance spectra

Michael Blaschek[1], Pierre Roudier[1], Matteo Poggio[1], Carolyn Hedley[1]
[1]*Manaaki Whenua - Landcare Research, Palmerston North, New Zealand*

The sustainable management of agricultural land requires reliable information about soil physical properties. Among these properties, available water-holding capacity (AWC) is a key attribute. Direct measurements are costly and time-consuming which is why pedotransfer functions (PTF) are commonly used for estimating AWC, leveraging statistical relationships with properties that are easier to measure, such as texture, bulk density, and organic carbon content. This study evaluates visible near-infrared spectroscopy (Vis-NIR) as an alternative to PTF to predict volumetric water content at field capacity (FC) and permanent wilting point (PWP) – AWC being the difference between PWP and FC.
A set of 930 Vis-NIR soil spectra, recorded from air-dried, 2-mm, sieved soil samples were associated with FC and PWP analytical data obtained from New Zealand's National Soils Database. Partial least squares (PLS) regression and support vector machines on PLS latent variables (PLS-SVM) were used for spectroscopic modelling. Final estimates showed promising results with respect to FC with a root mean squared error (RMSE) below 6%, while even more accurate predictions were found for PWP with a RMSE below 4%.
Our results indicate that Vis-NIR spectroscopy can be used to quantitatively predict key soil physical properties and support vector machines on PLS latent variables are an appropriate tool to do so. Setting up large spectral libraries holds potential to speed acquisition of soil data, which then helps understanding the critical processes that impact on management of our fragile national soil resource.

Assessment of soil organic matter stratification in two pastoral soils following full inversion tillage-renewal

Roberto Calvelo Pereira[1], Matteo Poggio[2], Michael J. Hedley[1], Michael Blaschek[2], Carolyn Hedley[2], Mike Beare[3], Sam McNally[3]

[1]Massey University, Palmerston North, New Zealand, [2]Manaaki Whenua-Landcare Research, Palmerston North, New Zealand, [3]The New Zealand Institute for Plant & Food Research Limited, Lincoln, New Zealand

Increasing soil organic carbon (SOC) may enhance sustainable production while offsetting greenhouse gas emissions from agriculture. Recent studies have suggested that infrequent full inversion tillage at pasture renewal (FIT-renewal) can help to accelerate SOC storage. Pastoral soils suited to respond positively to FIT-renewal show a contrasting vertical stratification of carbon that creates the opportunity to use deep ploughing to alter the depth-distribution of C-rich topsoil. Deep ploughing will both (1) transfer carbon-rich topsoil into the subsoil (slowing its decomposition), and (2) introduce litter and roots of the renewed pasture to the inverted subsoil (which is unsaturated in carbon). Changes in SOC storage and stratification need to be monitored closely due to spatial (paddock/farm scale) and temporal (over consecutive years) variability. Two field trial sites were set up in the Manawatu-Wanganui area, on a Pallic soil and on an Allophanic soil. Soils were deep ploughed (approx. 25 cm) and re-sown with turnip as a summer crop; other treatments included were shallow (5 cm) till and no till. The site was core sampled (0-40 cm) before cultivation and after 5 months of turnip growth to assess changes in SOC and stratification by using (1) laboratory-based analytical methods and (2) proximal sensing methods. At each site, deep cultivation transferred SOC below 10 cm depth, as expected. This one-time deep ploughing event did not homogenise the soil profile at the paddock level, but created a complex lateral variability instead. The hyperspectral reflectance scanning of the cores allows the soil carbon profile to be described in greater resolution by depth allowing researchers to make choices about the plough settings used prior to FIT-renewal. The information gained brings the application of FIT-renewal closer to widespread on-farm use in New Zealand by informing farmers on soil tillage history.

SWAMP3: The S-map soil water characterisation initiative

Sam Carrick[1], Linda Lilburne[1], Gerard Grealish[2], Stephen McNeill[1], Veronica Penny[1], Thomas Caspari[1], Balin Robertson[6], Kirstin Duess[6], Peter Almond[6], Andre Eger[1], Malcolm McLeod[3], Steve Thomas[4], Iris Vogeler[5], Christian Zammit[7], John Dando[2], Iazak Eksteen[2], Danny Thornburrow[3], Nina Koele[1], Nadia Laubscher[3]

[1]Manaaki Whenua, Lincoln, New Zealand, [2]Manaaki Whenua, Palmerston North, New Zealand, [3]Manaaki Whenua, Hamilton, New Zealand, [4]Plant & Food Research, Lincoln, New Zealand, [5]Plant & Food Research, Auckland, New Zealand, [6]Lincoln University, Lincoln, New Zealand, [7]NIWA, Christchurch, New Zealand

Knowledge of soil water storage and movement has become central to the sustainable management of New Zealand's freshwater resources. Regulatory implementation of the National Policy Statement for Freshwater Management 2014 is seeing an increasing demand for quantitative soil water attribute data of known accuracy and consistency across the different scales of decision making, from farm to catchment level. However, historical progress towards characterisation of soil water attributes in NZ has been limited, with the National Soil Data Repository (NSDR) containing measured data for just 313 sites from historical Soil Bureau research, compared to the 4800 soil siblings that S-map has identified in the 30% of NZ mapped so far. Because of the high cost to characterise soil water attributes, it is not possible to measure these attributes for all soils, so S-map uses pedotransfer functions (PTF's) to model attributes for soil siblings, based on the measured data in the NSDR.

Recognising the keystone importance of soil water data, S-map has put together a multi-agency consortium to initiate a series of co-ordinated projects (SWAMP3) aimed at a step-change improvement in the soil water data available for NZ. In the last year this has involved projects to: 1) Design a statistically robust NZ wide sampling scheme to maximise the cost benefit of collecting new data; 2) Identifying data from legacy projects, with over 150 of these sites now uploaded into the NSDR; 3) Commencing a field programme to sample at least 150 new soil profiles in three years; 4) Research to compare the effects of land management on soil water properties; 5) Preparation of lysimeter datasets for inverse modelling of soil hydraulic properties; and 6) Developing and publishing a PTF modelling framework that quantifies the uncertainty of predicting soil water attributes. This presentation will summarise SWAMP3, as well outline future directions.

Soil climate and active layer depth monitoring, Ross Sea Region, Antarctica

Annette Carshalton[1], Dr Megan Balks[1], Prof Karin Bryan[1], Dr Tanya O'Neill[1], Cathy Seybold[2]
[1]*University Of Waikato, Hamilton, New Zealand,* [2]*NRCS, USDA, Lincoln, United States of America*

The depth of seasonal thaw (the active layer, ALD), integrates a range of soil and atmospheric climate variables and has the potential to provide a clear signal of a changing climate. Nine soil climate monitoring sites were established between 1999- 2012 and are currently operating in the McMurdo Dry Valleys.
At each monitoring station, soil temperatures are measured at a range of depths down to 120 cm.
Wind speed and direction, air temperature, relative humidity, and solar radiation are also monitored.
Atmospheric data are measured every 10 seconds, and soil temperature every 20 minutes, with hourly means recorded. Data validation has been carried out through the comparison of multiple sensors and has given confidence to the current data-set.
Analysis of the data between 1999 – 2016 has found a moderate inverse correlation between ALD and altitude (R2 = 0.7), but no correlation between ALD and latitude. No distinct warming or cooling trends have been detected over the length of the record, but there is marked variability between seasons. The database provides a baseline for which future change can be assessed, with the database becoming more valuable the longer it runs. This paper will present the patterns found in ALD across the data, including the data from two sites not previously presented.

Revitalising the National Soils Database

Thomas Caspari[1], David Medyckyj-Scott[1], Alistair Ritchie[1], Juliana Osorio-Jaramillo[1], Gerard Grealish[1], Sam Carrick[1]
[1]*Manaaki Whenua - Landcare Research, Lincoln, New Zealand*

Soil point-based information serves as the 'base unit' for soil databases. Detailed site and soil descriptions help us understand soil formation and variability, inform soil classification, and are vital for mapping and modelling. New Zealand's central repository for soil point-based information is the National Soil Database (NSD), featuring comprehensive information for 1,500 soil profiles across the country. Mainly due to a lack of funding, it has been a 'sleeping beauty' for the last 25 years, and soil data gathered since the mid-1990s were spread over multiple locations, in a variety of formats, and at high risk of loss.
With a renewed recognition of the importance of soils information, the nationally significant collections and databases funded LRIS programme began work to revitalise the NSD. Effort focused on two major areas: 1) the design and implementation of a world class soils observation data system able to meet today's needs for soil data, and 2) a tool and workflows for capturing new and 'legacy' soil data.
The resulting National Soils Data Repository (NSDR), which has been in existence now for 2 years, is a versatile soil observation database that hosts the original NSD and has potential for many more datasets. Access to NSDR is via a web viewer application. New is an associated data entry tool that provides access, over the web, to the NSDR system. It allows data to be captured and updated, links associated lab analyses, and helps ensure that the data meets appropriate rules for quality and content.
In response to external requests, soil legacy data from over 150 sites have been uploaded into the NSDR in 2017/18. The focus was on sites that have soil water holding capacity data available, which have been used to validate S-map information, and ultimately will help improve land management and water quality decision-making.

Influence of soil properties on the uptake of cadmium in selected agricultural crops

Jo Cavanagh[1], Kiran Munir[1], Zicheng Yi[2], Nik Lehto[2], Brett Robinson[3], Colin Gray[4]
[1]Manaaki-Whenua Landcare Research, Lincoln, New Zealand, [2]Faculty of Agricultural and Life Sciences, Lincoln University, Lincoln, New Zealand, [3]3School of Physical and Chemical Sciences, University of Canterbury, Christchurch , New Zealand, [4]AgResearch, Lincoln, New Zealand

Plant uptake of cadmium (Cd) from soil is a key factor affecting food chain transfer. The uptake of Cd by plants is influenced by a number of factors, including crop species and cultivar, and soil properties such as pH and carbon. Identifying the key soil properties influencing plant uptake provides opportunities for minimising plant uptake and ensuring compliance with regulatory food safety standards. An extensive survey of cadmium in soil and in potatoes, onions and leafy greens in key growing areas across New Zealand recently undertaken, failed to reveal or revealed only weak relationships between plant cadmium concentrations with soil properties typically considered to be dominant influences on plant-uptake (e.g. soil cadmium concentrations, pH, total carbon). However, marked regional differences were observed in the uptake of cadmium in these crops, with lower plant uptake (expressed as the ratio of plant concentration to soil concentration) typically observed in Pukekohe and Matamata (Central Waikato) regions, which are dominated by Granular and Allophanic soils, compared to most other regions. This paper presents the results from an extended range of analyses, including oxalate extractable aluminium and iron, clay minerals analysis, phosphate retention and sequential extraction, on a subset of soil samples. The latter uses a series of different extraction reagents to indicate the soil fraction to which cadmium is bound. Marked differences were observed between soils and provides further insight into the influence of a wide range of soil properties on plant uptake of cadmium that will assist in ongoing management.

A new landscape-scale framework to analyse crop responses to climates and soils across New Zealand

Edmar Teixeira[1], Anne-Gaelle Ausseil[2], **Rogerio Cichota**[1], Jing Guo[2], Wei Hu[1], Linley Jesson[1], Sathiyamoorthy Meiyalaghan[1], Paul Johnstone[1], John Powell[3], Hymmi Kong[1], Linda Lilburne[2], Andrew Tait[3]
[1]Plant & Food Research, Lincoln, New Zealand, [2]Manaaki Whenua Landcare Research, Lincoln, New Zealand, [3]The National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand

Here we present the prototype of a new spatial analysis framework to quantify interactions between climates and soils on crop performance across New Zealand. The framework implements the process-based APSIM model within a high performance computing environment to enable assessments of crop performance at 5 arc-min resolution (~5 km grid size) using daily weather data from the National Institute of Water and Atmospheric Research (NIWA) for current and future climate change scenarios in combination with the S-map soil database from Manaaki Whenua Landcare Research. The S-map engine translates soil survey information into a comprehensive spatial representation of parameters used as input in biophysical models. We illustrate the potential applications of the framework through a preliminary case-study to assess climate change impacts in response to contrasting soils at a catchment scale. The effect of soil variability on model outputs for productivity and environmental aspects of agricultural systems was assessed for different climate scenarios considering a combination of General Circulation Models (GCMs) and Representative Concentration Pathways (RCPs). Results highlight the relevance of considering spatial variability in soils when performing climate change impact assessments for agricultural systems at regional scale. Insights from this study can inform future development of impact analysis tools to quantify the response of agricultural systems to climates and soils in New Zealand.

Understanding the spatial distribution of treading damage risk across farmlands

Dr Seth Laurenson[1], **Dr Rogerio Cichota[2]**, Mr Russel McAuliffe[1], Mr Nick Evans[3]
[1]AgResearch, Lincoln, New Zealand, [2]Plant & Food, Lincoln, New Zealand, [3]AgriOptics, Methven, New Zealand

The New Zealand dairy industry seeks to develop agricultural production systems that can simultaneously achieve increased production and profitability targets with lower environmental impact. Dairying systems in this country are largely pasture-based where the impacts of cow treading damage to soil and pastures are widespread and generally viewed as inevitable. Treading damage in the form of soil compaction and pugging, places limitations on important biological functions, damages the pasture sward and increases the overland flow contaminants during rainfall events. The extent of treading damage across farms differs due to a number of site-specific factors such as topography, soil type, climate and management. We have developed a tool that can help identify treading damage risk and guide farmers towards the most effective means of management across an individual farm. A combination of component-based field trials and field validation surveys, biophysical and hydrological modelling as well as electromagnetic surveying and GIS mapping enabled us to identify the spatial distribution of the treading damage risk across a farm in Southland, NZ. Our tool considered soil type, cow grazing events, frequency of wetting during the year (based on 30 years of climate data), duration of wetness following a rainfall event and redistribution of surplus water that resulted in surface ponding. An animal treading model developed in APSIM enabled us to consider the interactions between multiple bio-physical processes that occur during the period of natural soil/pasture recovery following a compaction event. For the case study farm, treading damage resulted in a loss of pasture up to 40% in areas of the farm where water accumulated due to the micro-topography and where soils had a clay content above 25%v/v. Mitigation action plans developed using this tool will assist farmers avoid the adverse effects of treading damage on pasture production and the environment.

Assessment of the nitrate attenuation capacity of a seepage wetland in a hill country landscape

Grace Chibuike[1], Lucy Burkitt[1], Marta Camps Arbestain[1], Ranvir Singh[1], Mike Bretherton[1], Peter Bishop[1]
[1]School of Agriculture and Environment, Massey University

Due to the unique features of hill country landscapes, agricultural production on these landscapes potentially possesses adverse environmental impacts on water quality. Despite the complex nutrient loss pathways in hill country agricultural landscapes, the naturally occurring wet areas (seepage wetlands and hillside seeps) in these landscapes have the potential to attenuate nitrate, thus reducing its leaching to ground and surface waters. However, the denitrification capacity and dissolved organic carbon (DOC) concentration and chemistry of these wet areas relative to adjacent drier areas in the landscape have not been quantified. This study investigated the denitrification capacity, and DOC concentration and chemistry of wet areas and adjacent dry areas within a hill country paddock, located in Palmerston North, New Zealand. Soil samples were collected during spring from different soil depths down to 1 m. The results show that the seepage wetland had significantly higher ($p \leq 0.05$) DOC concentration compared to the hillside seep and dry area. Mean DOC concentration in the surface 30 cm depth was in the following order: seepage wetland (498 mg/kg) > hillside seep (172 mg/kg) > dry area (109 mg/kg). The denitrification capacity of the seepage wetland within the 0-30 and 30-60 cm depths was 7 and 69 times greater, respectively, than that of the dry area. The higher DOC concentration and the presence of readily-decomposable (lower molecular weight) DOC in the seepage wetland contributed to its higher denitrification capacity. The contrasting nitrate attenuation capacities of the hill country seepage wetland versus that of dry areas highlights the potentially important contribution of these seepage wetlands to attenuate nitrate and thus improve water quality. It also suggests that contrasting management practices (such as maintaining/enhancing DOC levels) are required for these distinct areas, if nitrogen loss restrictions are imposed on hill country farms in the future.

Soil, Carbon, and Water: Natural Capital Delivering Valuable Ecosystem Services

Dr Brent Clothier[1]
[1]*Plant & Food*

Nature comprises an assemblage of natural capital stocks which form our ecological infrastructures. Soils and plants are key components of our ecological infrastructures. They are our prime natural-capital stocks that provide valuable and essential ecosystem services. Of the four ecosystem service classes, we focus here on the two of how soil and plant hydrological processes deliver the provisioning services, along with the regulating services of the buffering and filtering water, carbon, and nutrients. We consider how soil hydrological processes in the saline desert sands of the hyper-arid UAE serve to maintain provisioning and regulating services through irrigation, and especially how alternative water sources can be used to protect dwindling groundwater stocks. We also show how management of avocado trees in the Kenyan highlands regulates the service of soil-water delivery to the trees, and that how an understanding of the regulating services of weather can predict, via a Decision Support Tool, the provisioning service of avocado production. Finally we show how reference to natural capital and the ecosystem services might be incorporated into policy to maintain profitable provisioning services whilst sustaining regulating services. This should also guide us in making land-use decisions for a 'low emissions' economy to mitigate climate change.

Empirical evidence for the existence of labile and passive soil organic matter pools

Denis Curtin[1], Mike Beare[1], Weiwen Qiu[1]
[1]*Plant & Food Research, Christchurch, New Zealand*

Soil organic matter (SOM) turnover is a topic of much interest within the soil science community. In recent years there has been a proliferation of fractionation schemes aimed at separating SOM into pools with distinct properties, including turnover rates. However, even highly complex, multi-fraction schemes have not have proved entirely satisfactory. In contrast, work in New Zealand using time-series radiocarbon data suggests soil C turnover can be explained by a simple two pool model (SOC divided into "passive" and "labile" pools). Long-term agro-ecosystem experiments have been a valuable source of information on factors influencing SOM dynamics. Over decadal time scales, changes in SOM in response to management are mostly due to changes in the actively-cycling component whereas the passive fraction should not be affected. We used data from a field trial (at Lincoln) with a wide range of soil and crop management treatments in a case study to determine if SOM bioavailability (C and N mineralisation measured in a 14-week incubation at 25oC) is consistent with a two-pool. The results indicated that the soils contained a constant quantity of passive organic matter, but mineralisable organic matter varied depending on treatment and sampling depth. There was a strong correlation between the mineralisable fraction and hot water extractable C. We concluded that solubility of SOM in (hot) water is an important determinant of its bio-availability. Insoluble organic matter, including SOM that is strongly bonded to mineral surfaces, appears to comprise a significant part of the passive fraction.

RHIZO-ID as a novel technology for direct rhizobia identification

Dr Sofie De Meyer[1], Dr Sofie De Meyer[2], Valentin Pflüger[3], Dr Guido Vogel[3]

[1]Maldiid Pty Ltd, Murdoch, Australia, [2]Centre for Rhizobium Studies, Murdoch, Australia, [3]Mabritec AG, Riehen, Switzerland

In recent years clover pastures have been struggling around Australia and have therefore become a less reliable source for animal production. Consequently, this project aimed to understand if the lack of good quality inoculant rhizobia in the legume root nodules was contributing to this decline. Bacterial identification is a tedious and very time-consuming job and therefore alternative technologies were explored to identify rhizobia. RHIZO-ID™ was developed for rapid and efficient root nodule bacteria identification without the need to culture the bacteria. This novel method determines protein markers to detect the different strains and their unique fingerprints. Specifically, it utilises MALDI-TOF MS specific selected protein markers rather than full spectra comparisons to distinguish between different rhizobia strains and allows differentiation of current inoculant strains, old inoculant strains and background/native rhizobia. This novel technology has been utilised to analyse commercial pasture paddocks across Australia. The RHIZO-ID™ results were analysis in relation to paddock establishment age, inoculant history, nodule score, pH and herbicide usage for each of the investigated regions and this is presented. Further, pasture improvement strategies are suggested for the different pasture cases.

Is the ridge and furrow bed architecture limiting potato production?

Steven Dellow[1], Alexandre Michel[1], Sarah Sinton[1], Steve Thomas[1], Kate Richards[2]

[1]The New Zealand Institute for Plant & Food Research Limited , Lincoln, New Zealand, [2]The New Zealand Institute for Plant & Food Research Limited , Mt Albert, New Zealand

Management of water supply to potato crops can have a major influence on final yield and quality. A crop survey conducted by PFR in 2012-13 noted that high intensity irrigation events often contributed to considerable water run-off along furrows under the conventional ridge/furrow bed architecture. Ridge shape combined with degraded soil structure caused by intensive cultivation meant there was reduced water infiltration into ridges, where the majority of potato roots are located. Following these observations, a potato ('Bondi') field trial in Lincoln in 2015/16 compared the conventional ridge/furrow bed with a flat-bed under a non-limiting and a drought-inducing irrigation regime, on a well-drained Wakanui silt loam. Fresh tuber yield increases of 5.6 and 2.2 t/ha were recorded for the flat-bed over those of the ridge/furrow treatments under non-limiting and a drought-inducing irrigation respectively. Results suggested that the flat-beds could store up to 7% more plant available water than ridge/furrow treatments, as increased macropores within the ridge led to increased drainage. A separate field trial exploring bed architecture was conducted on an irrigated potato ('Russet Burbank') crop in mid-Canterbury in 2017/18. Flat-beds were compared with flat-top ridge/furrow under 'shallow' and 'deep' seed depth, on a shallow well-drained Lismore silt loam. Marketable yield and water use under the flat-bed architecture were 84 t/ha and 702 mm respectively, and were higher than in the flat-top ridge/furrow, with 81 t/ha and 643 mm respectively. Planting depth had an effect on potato water use, with shallow and deep using 696 and 650 mm respectively, which translated to lower water-use efficiencies (119 and 127 kg fresh tuber/mm water respectively). Thus the use of flat-bed architecture could improve yields through increased plant-available water storage over the conventional and flat-top ridge/furrow bed architectures. Benefits may be more pronounced in soils with low water-holding capacity and/or limited/no irrigation.

Using laboratory soil incubations to study the nitrogen cycle

Moira Dexter[1]
[1]*AgResearch, Hamilton, New Zealand*

Laboratory soil incubations are an important technique to understand the effects of different additives (e.g. fertilisers, nitrification inhibitors and effluents) on nitrogen (N) transformations in soil. These studies are typically used prior to field evaluation since they can test a large number treatments under controlled laboratory conditions (e.g. soil temperature and moisture content) for detailed soil N measurements.

The methodology for soil incubations are broadly categorised into closed or open incubations and offer the ability to measure gaseous, leachable and/or extractable soil N pools. An open soil incubation refers to one where the soil is set up in a column and the N in the soil is removed periodically through a leaching process. A closed soil incubation refers to one from which a subsamples of soil are removed and extracted but nitrogen is not removed from the remainder of the incubated soil. A closed incubation can either be run with large replicated treatments that are subsampled periodically or individual subsample-size replicates that are destructively sampled at different time points. Each type of soil incubation has advantages and disadvantages that should be carefully considered when designing the experiment.

The most commonly employed incubations in our work are closed incubations done on bulked replicated samples that are subsampled periodically, and sometimes run in conjunction with soil incubated in gas-tight jars for gaseous flux measurements. The majority of this work is focused on understanding the effect of treatments on ammonification or nitrification rates, determining mineralisation rates of effluents, and materials ability to adsorb N or determining rates of mineralisation and/or immobilisation.

This presentation will discuss some of the factors and limitations to consider in the design of a laboratory soil incubation and present some general findings.

Plant-based protein: A sustainable protein source meeting future opportunities?

Karin Müller[1], **Carlo van den Dijssel**[2], Edmar Teixeira[3], Alistair Hall[2], Adrian Hunt[4], Brendon Malcolm[3], Paul Johnstone[4], Brent Clothier[2]
[1]*Plant & Food Research, Hamilton, New Zealand,* [2]*Plant & Food Research, Palmerston North, New Zealand,* [3]*Plant & Food Research, Lincoln, New Zealand,* [4]*Plant & Food Research, Havelock North, New Zealand*

In recognition of the need to protect natural resources for future generations New Zealand has developed regulations for freshwater management and set ambitious greenhouse gas emission targets. A tax on carbon emissions seems likely. All of this adds to the increasing pressure on traditional production systems, of which some are perceived to contribute largely to the degradation of water quality and the country's greenhouse gas emissions profile. Furthermore, there are increasing opportunities for foods based on plant-derived proteins. In response to the 'carrots & sticks', land managers and decision makers show increasing interest in alternative land use options, which are profitable and address environmental pressures. In this pilot study we are exploring opportunities to expand the production of food crops with high protein-value in New Zealand. We focused on a selection of crops already grown in the country, such as peas and potatoes. Using a GIS-based analysis we have assessed the potential land area that these crops could cover by identifying the most suitable lands and climate. In addition, we quantified biological greenhouse gas emissions, irrigation requirements, and nitrogen leaching to verify claims that plant-based proteins have low production footprints. We provide evidence of the sustainability for growing plant-based protein crops in New Zealand and outline where these crops could be grown under current climates, and those predicted in the future.

Using land information and the Ecosystem Approach for farm planning and system design

Dr Estelle Dominati[1], Dr Alec Mackay[1], Dr John Rendel[2], Dr Fleur Maseyk[3]
[1]AgResearch, palmerston north, new zealand, [2]AgResearch, Mosgiel, New Zealand, [3]The Catalyst Group, Palmerston North, New Zealand

The last 20 years have seen remarkable progress in recognising the value of soils beyond their agronomic value towards characterising their role in sustaining healthy ecosystems and thereby economies and societies.
To capture the recognition of the central role soils play in sustaining the provision of all ecosystem services, land evaluation and farm planning need to re-invent themselves in order to enable the quantification of all benefits obtained from farm landscapes.
Here we explore how several disciplines, including Mātauranga Māori, can be brought together to advance land evaluation and assist in designing farm systems that are not only sustainable and operate within environmental boundaries but also performant as businesses and provide cultural and social benefits to society.
Land evaluation has a long history of describing and quantifying the productive capacity of soils. However there is a need for this discipline to evolve and recognise all services provided by landscapes as well impacts on receiving environments.
Ecological theory informs the relationship between stocks and processes and supports the premise that the manipulation of key stock attributes changes ecosystem function and service provision.
Te Ao Māori is a holistic worldview linking all components of natural environments together with people. This has strong similarities with the Ecosystem Approach.
Finally, farm planning, which focuses more on socio-economic constraints to the production system, is the tool enabling strategic planning at the farm scale.
We suggest that the combination of these disciplines enables more of the interactions between natural capital, which includes soils, vegetation and waterways, built capital and people, to be investigated.
We will demonstrate through a series of examples how the use of next generation farm plans based on Mātauranga Māori and the Ecosystem Approach and new modelling analytical capabilities can help bring together business, environment and cultural goals while focusing on farm performance.

Temporal changes in soil physical properties under irrigated cropping

John Drewry[1], Sam Carrick[2], Stephen McNeill[2], Steve Thomas[3], Ian Lynn[2], Andre Eger[2], John Payne[2], Graeme Rogers[2]
[1]Manaaki Whenua - Landcare Research, Palmerston North, New Zealand, [2]Manaaki Whenua - Landcare Research, Lincoln, New Zealand, [3]The New Zealand Institute for Plant & Food Research Ltd, Lincoln, New Zealand

Soil physical properties affect water and air transmission through soil, water storage, and water availability to crops and pasture. Temporal changes in soil hydraulic, water retention, and physical properties, however, have not been well studied. The temporal change of these properties is a key knowledge gap in improving our understanding of processes. Improving our knowledge will help with modelling physical processes including links to biological and chemical processes and cropping and irrigation practices in temperate climates. Soil physical properties can change due to processes including rain and irrigation action, wetting and drying, plant and root growth and root decay, soil fauna and flora activity, and soil compaction. The study examines temporal changes of soil hydraulic conductivity, water retention, and other physical properties at the Foundation for Arable Research's Chertsey site in Canterbury. The field experiment was established to evaluate temporal change in physical properties under ploughed and direct-drill treatments. The trial plots were sown with oats. Nine soil samplings were undertaken from May 2015 to January 2016. Soil physical properties measured included temporal change in saturated and unsaturated hydraulic conductivity, a wide range of pore size distribution, and soil water storage properties. We will present a selection of preliminary results.

Soil and crop sensing technologies informing best application of irrigation water

Mr Ahmed El-Naggar[1], Dr Carolyn Hedley[2], Dr David Horne[3], Dr Pierre Roudier[4], Dr Brent Clothier[5]
[1]Institute of Agriculture and Environment, Massey University, Palmerston North, New Zealand, [2]Manaaki Whenua – Landcare Research, Riddet Road, Massey University Campus, Palmerston North, New Zealand, [3]Institute of Agriculture and Environment, Massey University, Palmerston North, New Zealand, [4]Manaaki Whenua – Landcare Research, Palmerston North, New Zealand, [5]Plant & Food Research, Palmerston, New Zealand

Precision irrigation aims to improve irrigation water use efficiency (IWUE) by better targeting of water to meet the site-specific water requirements of plants and to reduce negative environmental impacts. As precision irrigation equipment such as variable-rate sprinkler systems become increasingly available to agricultural producers in New Zealand, our research aims to determine how to best manage irrigation to optimize crop yield and the use of water resources.
The challenge is to develop a decision support tool that informs scheduling at appropriate scales, taking into account the spatial and temporal variability of soil water supply to growing crops. Therefore, a method has been developed to map soil variability spatially and with depth resolution, using a quasi-2 dimensional inversion algorithm to process apparent soil electrical conductivity survey data collected by electromagnetic sensors (i.e. DUALEM-421 and DUALEM-1S). This is then used to guide placement of a connected soil moisture sensing network to monitor soil moisture and inform irrigation scheduling.
A trial was conducted, in a two-year study, to compare this sensor-based scheduling with irrigation scheduling based on a soil water balance. Pea and bean crops were grown under a variable rate irrigation system on a variable recent soil at Massey University No.1 Farm.
The results indicated that the sensor-based scheduling technique delivered 15% to 30% less water and reduced drainage from the sandy soil by 23 mm compared to the soil water balance approach. As there were no significant yield differences between the two approaches, IWUE was greater under the scheduling regime based on sensors. Further research is planned to assess the feasibility of including this monitoring system into a precision irrigation control system.

Effect of different wood chip material on nitrogen leaching from stand-off pads

Juergen Esperschuetz[1], Alvand Azimi[2], Brett Robinson[3], Henry Chau[2], Mark Bloomberg[1]
[1]University of Canterbury, School of Forestry, Christchurch, New Zealand, [2]Lincoln University, Faculty of Agriculture and Life Sciences, Lincoln, New Zealand, [3]University of Canterbury, School of Physical and Chemical Sciences, Christchurch, New Zealand

In New Zealand farming systems, stand-off pads are used to reduce pugging and nutrient leaching, and provide comfortable areas for stock to lie during periods when soil water content is near saturation. They are normally covered with a durable free-draining material such as stones, limestone or wood residues such as woodchips or tree bark. The use of woodchip material for stock bedding areas can absorb chemical (N, P, K) concentrations derived from dung and urine from livestock, and can therefore be a potential solution to reduce nitrate leaching, especially during winter, when there is limited vegetation and growth. Due to different contents of plant secondary metabolites and hormones, woodchips from different tree species can have a distinct influence on the transformations of nutrients.
In a greenhouse experiment, a cow urine simulation of 850 kg N per ha has been applied to lysimeters containing willow, poplar and pine woodchip material. The nitrogen speciation in leachate has been analyzed over a 50-day period under a continuous irrigation scheme of 4mm/day. Results show a significantly reduced nitrate leaching in willow treatments compared to poplar and pine, while ammonia concentrations in willow were significantly higher than measured in leachate from poplar or pine woodchips. These results indicate potential nitrification inhibition properties of willow phytochemicals, which could be beneficially used in farm systems to mitigate nitrate leaching.

Using stable-carbon isotope to understand the role of organic amendments in ameliorating poorly structured sodic-subsoil

Yunying Fang[1], Bhupinder Pal Singh[1], Zhe Weng[2], Mark Farrell[3], Roger Armstrong[4], Ehsan Tavakkoli[2,5]
[1]NSW Department of Primary Industries, Australia, menangle, Australia, [2]NSW Department of Primary Industries, Wagga Wagga, Australia, [3]CSIRO Agriculture & Food, Urrbrae, Australia, [4]Agriculture Research, Department of Economic Development, Jobs, Transport and Resources, Horsham, Australia, [5]Graham Centre for Agricultural Innovation, Charles Sturt University, Wagga Wagga, Australia

Application of organic amendments (OA) to ameliorate sodic subsoils and to improve soil aggregation has gained great interest. However, the mechanistic linkages between the decomposition processes of OA, microbial carbon (C) use efficiency, and the formation of soil aggregates in sodic soils are still unclear. In a laboratory incubation experiment at 20°C, a C3 Sodosol (δ13C-SOC: -24‰) from 20–40 cm depth was uniformly mixed with C4-vegetation OA (including sorghum stubble, bagasse, sugar press mud and/or press ash), with or without gypsum, or nutrients. The distribution and dynamics of OA- and native SOM-derived C in total CO2 respiration and microbial C use efficiency have been examined by using δ13C at natural abundance. Soil aggregation and the fate of OA-derived C in aggregates (macro-aggregates, micro-aggregates and silt-clay) are being determined over time. After 31 days of incubation, the OA-C mineralisation was in the order of sorghum > bagasse > press mud ± press ash, and the nutrient application increased OA-derived C mineralisation relative to non-nutrient or gypsum treatments. The application of OA in the soil significantly increased the loss of native SOC ("positive priming"), in the order of sorghum > bagasse, press mud ± press ash. These preliminary results showed that the application of nutrients along with the amendments increased the turnover of OA-derived C. This may have increased the production of OA-derived microbial residues and their incorporation in aggregates-associated C pools, with potential to increase SOC storage and the formation of macro-aggregates. The results of (i) microbial use efficiency of OA-derived C, (ii) distribution of OA-derived C in different aggregates will be presented at the conference. Our study helps to address knowledge gaps relating to the impacts and mechanisms of biological decomposition of OA and soil aggregate formation, with implications for improving crop yield in dispersive sodic-soils.

Developing tools that build understanding of soils in the landscape

Scott Fraser[1], Peter Singleton[2]
[1]Manaaki Whenua Landcare Research, Hamilton, NZ, [2]Natural Knowledge, Hamilton, NZ

Effective management of terrestrial resources requires some understanding of soil-landscape relationships. Using tools that help land managers understand these relationships with respect to particular land management issues, such as managing nutrients, contaminants or biodiversity could be a cost effective way to assess land, particularly if expert pedological advice is not readily available or is cost prohibitive. However, a challenge of extension of soil-landscape knowledge is to convey complex pedological concepts in a way that can be easily assimilated.
Three examples will be presented to illustrate how soil patterns could be identified in the field by non-experts.
1)., Councils around the country are required to manage wetland biodiversity values and in order to do so they need to be able to clearly delineate wetland boundaries. Hydric soils are useful indicators for identifying wetlands when vegetation types do not provide conclusive evidence (e.g. the presence of facultative wetland species).
2), Waikato dairy farmers need to assess risk with respect to application of effluent on peat soils in order to satisfy regional council requirements around effluent disposal.
3), In many areas now farmers are required to develop farm environment plans in which soil information is integral. Most farms do not have soil spatial information at farm scale, however, in order to mitigate environmental effects there is increasing need for detailed soil information. The S-map database holds detailed soil profile data, but most S-map spatial layers are only 1:50,000 scale. Soil-landscape models developed during S-map soil surveys could provide farmers or consultants with tools to develop farm scale soil maps from a 1:50,000 S-map layer.
Each of these examples presented different challenges and these will be discussed along with ideas on how complex pedological ideas could be more effectively conveyed to a wider audience.

Effect of biochar on plant growth, soil biology and biochemistry in a 6-month mesocosm experiment

Stanislav Garbuz[1], Prof Marta Camps[1], Dr Alec Mackay[2], Brian Devantier[2], Dr Maria Minor[1]
[1]Massey University, School of Agriculture & Environment, Palmerston North, New Zealand, [2]AgResearch Grasslands Research Centre, Palmerston North, New Zealand

Purpose. Biochar is a multifunctional soil amendment which can provide a wide range of benefits to agricultural systems, including improving soil fertility through increased retention of nutrients, liming of acid soils, and mitigating climate change through carbon storage. Biochar also affects soil microbial community, soil fauna such as earthworms and arthropods, and soil biochemical and physical properties in ways which are still not well understood. In this study, we investigated the influence of biochar on soil physicochemical properties and soil functional biodiversity.
Material and Methods. Brown and Allophanic soils were used in a 6-month glasshouse experiment. Treatments included: no amendment (negative control), lime addition (positive control), and biochar addition. Biochar was produced from weeping willow chips pyrolysed at 350^{o}C. Each treatment had two variants: with or without earthworms Aporrectodea caliginosa. Plants (white clover) were grown in all pots. Soil properties, arthropods population, microbial community structure and enzyme activities were measured.
Results. Biochar and earthworms had a considerable effect on soil nutrients content and their depth distribution. Also, adding biochar and earthworms significantly increased ($P < 0.05$) microbial community and arthropod numbers. All treatments significantly ($P < 0.05$) modified biochemical properties of the soils in different ways (e.g., an increase in alkaline phosphatase by biochar, increase in nitrate reductase by lime). The different effects of lime and biochar despite being added by identical liming equivalents, suggests that added alkalinity was not the main effect of biochar on measured soil properties. Combining biochar and earthworms had a significant ($P < 0.05$) positive effect on plant growth. Overall, we showed that biochar increased plant growth through its changing soil physicochemical and biochemical properties, without having a negative effect on soil biota. In some cases, there was a synergistic effect of earthworms with either biochar or lime.

Mitigating urine patch nitrous oxide emissions via the urinary excretion of plant secondary metabolites

Camilla Gardiner[1], Tim Clough[1], Keith Cameron[1], Hong Di[1], Grant Edwards[1]
[1]Lincoln University

Pasture species may contain active plant secondary metabolites (PSMs) capable of inhibiting nitrification in soil. During grazing, ruminant livestock consume PSMs in their forage diet. Livestock may potentially excrete PSMs in their urine, thereby directly applying a nitrification inhibitor to the urine patch. The PSM, aucubin, in the pasture herb species Plantago lanceolata (plantain) was identified for its potential to inhibit nitrification in the urine patch. An autumn field trial was performed at Lincoln University with three treatments: Control, Urine, Urine + Aucubin. Urine from cows grazing perennial ryegrass (Lolium perenne) and white clover (Trifolium repens) was applied onto pasture at a rate of 500 kg N ha-1. Aucubin was mixed into the urine immediately before application, and applied at a rate that is equivalent to 10% of the highest calculated potential aucubin excretion rate from cows grazing plantain pasture (47 kg aucubin ha-1). Soil surface pH, inorganic nitrogen, and nitrous oxide emissions were monitored for 35 days after application. Statistically significant differences in soil NO3- concentrations and soil surface pH indicated that aucubin inhibited nitrification 4-7 days after urine application. However, this period of inhibitory activity was not sufficient to produce a significant reduction in N_2O emissions over the 35 day experiment. It was concluded that this rate of aucubin application in urine was not sufficient to reduce urine patch N_2O emissions.

Comparing deep soil carbon stocks under kiwifruit and pasture land use

Roberta Gentile[1], Carlo van den Dijssel[1], Nathan Arnold[2], Jian Liu[2], Karin Müller[3]

[1]The New Zealand Institute for Plant & Food Research Limited, Palmerston North, New Zealand, [2]The New Zealand Institute for Plant & Food Research Limited, Hawke's Bay, New Zealand, [3]The New Zealand Institute for Plant & Food Research Limited, Ruakura, New Zealand

Soil carbon is important natural capital for agricultural production, as it affects soil physical, chemical and biological functions and the provision of ecosystem services. Measures of land-use effects on soil carbon stocks generally focus on the top 0.3 m of soil, as the topsoil has the highest carbon concentration. However, while subsoil horizons have low carbon concentrations, they contain a greater absolute amount of carbon with longer mean residence times than topsoil layers). In the face of climate change, the potential of subsoils to sequester carbon needs quantifying. Perennial horticultural crops offer potential to store carbon deep in the soil profile because of their long-lived and deep rooting systems. A preliminary study using a single paired-site comparison found substantial amounts of carbon down to a depth of 9 m under kiwifruit compared with pasture. To investigate the hypothesis that kiwifruit can increase subsoil carbon stocks, we sampled soils from 20 paired kiwifruit and pasture sites in the Waikato and Bay of Plenty regions of New Zealand. Pasture was selected for comparison as it was the antecedent land use before kiwifruit. Paired land uses were located within 100 m of each other on the same soil type. Kiwifruit vines were at least 15 years old and the pasture had no cultivation during that time. Soil carbon stocks were assessed to a depth of 2 m. We present the findings of our soil carbon stock quantification and discuss the implications for understanding deep soil carbon sequestration potential and carbon distribution in soil profiles under different land uses.

Effect of Fluorine on Rhizobia growth and morphology

Mr Thangavelautham Geretharan[1], Dr Paramsothy Jeyakumar[1], Dr Michael Bretherton[1], Professor Christopher Anderson[1]

[1]Fertilizer & Lime Research Centre, Environmental Sciences, School of Agriculture and Environment, Palmerston North, New Zealand

New Zealand's agricultural soil fluorine (F) concentrations have increased as a result of continuous phosphate fertiliser application. These elevated soil F concentrations may have the potential to negatively impact soil microorganisms which underpin New Zealand's agricultural economy. In order to assess both total and bioavailable F concentrations in New Zealand agricultural soils, standard methodologies were developed at Massey University and applied to a suite of soil orders, giving a range of bioavailable F of 1.70 to 6.45 mg/kg; two orders of magnitude lower than that of total F.

Rhizobium leguminosarum, is a Nitrogen fixing soil bacteria which is a fundamental component of New Zealand's legume-based pastoral farming. Currently, there is no data available to determine if New Zealand's soil bioavailable F concentrations are harmful to Rhizobium.

A laboratory incubation experiment was conducted to measure the F toxicity to Rhizobium. Rhizobium cultures were exposed to a range of fluoride concentrations (0, 0.5, 1, 5, 10, 20, 50, 70, 100, 500 and 1000 mg/L) and added as three different F salts (NaF, KF and NH4F), with each treatment replicated three times, and incubated at 27°C for 48 hours. Rhizobium growth was measured by optical density (OD) at 600 nm after 24 and 48 hours of incubation, and morphological changes were imaged by scanning electron microscopy. The OD measurements indicate that Rhizobium growth was not significantly suppressed by fluoride concentrations less than 100 mg/L, regardless of the fluoride salt used. Further, the normal rod-shaped bacterium cell was morphologically altered when Rhizobium was exposed to fluoride concentrations above 100 mg/L. This concentration (100 mg/L) is orders of magnitude higher than those recorded for New Zealand agriculture soils under 'normal field conditions' (< 0.58 mg/L). Therefore, there is no indication of imminent risk of soil F to Rhizobium leguminosarum.

Dissolved gasses as indicator of denitrification process in shallow groundwater in agricultural landscape

Marcela Gonzalez[1], Ranvir Singh[1], Neha Jha[1], Andrew McMillan[2]
[1]Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand, [2]Manaaki Whenua-Landcare Research, Palmerston North, New Zealand

Excessive application of fertilizers in agricultural production systems may cause leaching and runoff of nitrate (NO3-) from soils to receiving groundwater and surface waters. However, leaching of NO3- can be affected by different flow paths and attenuation processes depending on physical, chemical, biological characteristics of soil water systems.

Denitrification in groundwaters is a key attenuation process where NO3- can be reduced to N2 (a harmless gas), offering an ecosystem service in terms of water quality protection. However, subsurface denitrification process does not always proceed to completion and intermediates such as the harmful greenhouse gas nitrous oxide (N2O) can be produced. There is very limited information available about potential occurrence, characteristics and dynamics of subsurface denitrification in shallow groundwater across New Zealand agricultural catchments.

We studied 6 pastoral farms located in various hydrogeological settings in Manawatu and Rangitikei Rivers catchments, in the lower North Island of New Zealand. We collect monthly samples and run push and pull tests to analyse groundwater redox parameters (dissolved oxygen (DO), oxidation-reduction potential, pH, NO3-, iron, manganese and sulphate) and dissolved N2O and N2 gasses in shallow groundwater. Our results indicate that subsurface denitrification is occurring in the study sites, however the terminal product of denitrification is spatially variable depending on redox status. We observed higher concentrations of dissolved N2 under reduced groundwater conditions, while dissolved N2O was observed to be the dominant product under oxic conditions, suggesting that the denitrification is incomplete at the oxic sites.

Our research will help to gain a better understanding of spatial variability of subsurface denitrification process it will also indicate targeted and effective management measures for sustainable agricultural production while protecting soil, water and air quality.

Carbon and nitrogen balances for irrigated and non-irrigated lucerne: insights to minimise losses.

Scott Graham[1], Johannes Laubach[1], John Hunt[1], Rowan Buxton[1], Graeme Rogers[1], Sam Carrick[1], Paul Mudge[2], David Whitehead[1]
[1]Manaaki Whenua - Landcare Research, Lincoln, New Zealand, [2]Manaaki Whenua - Landcare Research, Hamilton, New Zealand

There is increasing concern about the impacts of widespread conversion of dryland farming to intensive, irrigated dairy farming in dry, eastern areas, especially on shallow, stony soils prone to leaching. Production of lucerne as a fodder crop provides an alternative, high protein food supply and continued growth during dry summer months is attributed to its characteristic deep-rooting and nitrogen fixation. However, growth in winter is slow, leading to the possibility of high nitrogen leaching losses. Further, the performance of lucerne under irrigation with water and dairy effluent is not well known. To address these issues, we present annual carbon and nitrogen balances over 3 years for irrigated and non-irrigated lucerne from continuous measurements at paddock scale at Lincoln University's Ashley Dene Research & Development Station. This site is representative of widespread land use conversion to dairy farming. Despite high rates of annual above-ground production of 7.0 and 12.8 Mg dry matter ha^{-1}, biomass removal has resulted in net carbon losses increasing in the final year to 1.3 and 3.0 Mg C ha^{-1} for the non-irrigated and irrigated sites, respectively. Preliminary analysis of the annual nitrogen balance shows that, for non-irrigated lucerne, all nitrogen was derived from fixation, but this was removed in biomass with a small net loss of 16 kg N ha^{-1} via leaching. For irrigated lucerne, 71% of plant nitrogen was derived from fixation with additional uptake from soil or effluent. Leaching loss was 65 kg N ha^{-1} and the net loss was 84 kg N ha^{-1}. Although we estimate these annual net losses to be less than 3.2 and 1.6% of the soil carbon and nitrogen stored to a depth of 1.5 m, respectively, changes to the timing and frequency of management practices are needed to reduce carbon and nitrogen losses while maintaining productivity.

The potential for potassium chloride fertiliser applications to leach cadmium from a grazed pasture soil

Dr Col Gray[1], Prof Rich McDowell[1]
[1]*Agresearch, Lincoln, New Zealand*

Cadmium (Cd) is a toxic element that can enter the human food chain via plants grown in Cd-enriched soil. Chloride (Cl) can solubilise Cd in soil. Although fertilisers containing Cl are not recommended as they may increase plant uptake of Cd, potassium chloride (KCl) is regularly applied to replenish and maintain K in the soil of grazed pastures. A trial was conducted to see if an autumn application of low (0.02 mol L-1, equivalent to 30 kg K ha yr-1) or high (0.04 mol L-1) KCl and the same molar rates of CaCl2 (used as a check to other studies) would leach Cd over 4-months of normal (300-mm) or high (600-mm) autumn-winter rainfall without enriching Cd in plant shoots. Leaching losses of Cd were greater from the high KCl and CaCl2 treatments (1.80 and 1.70 g ha-1, respectively) than the low KCl treatment (1.27 g ha-1). All loads lost from the Cl treatments were greater than from the control treatment (0.53 g ha-1). Losses from Cl treatments represented 29-41% of the Cd applied in an annual application of 250 kg superphosphate ha-1. Pasture shoot Cd concentrations were not different to the control (mean = 0.088 mg kg-1). Applying Cl (e.g. as KCl) in autumn pasture may be a simple strategy to help decrease or slow the enrichment of soil Cd and does not increase the uptake of Cd by pasture.

Farm-scale soil mapping protocols for New Zealand

Gerard Grealish[1], Sam Carrick[1], Andrew Manderson[1]
[1]*Manaaki Whenua - Landcare Research, New Zealand*

Farm Environment Management Plans and nutrient budgeting is now a compulsory regulatory requirement in a number of regions across New Zealand, and are reliant on quality soil information as a key input. The soil mapping protocol presented here provides standards and guidance to be used nationally for collecting and presenting soil map information. This Envirolink tools project was initiated by Regional Councils to address the need to provide: a framework for consistent soil mapping, identification of appropriate methods, a process to determine if the work has met minimum standards, and guidance on the level of detail required for different land use applications. This was to overcome the variety of soil maps and differing standards of work that could otherwise be generated and provided.

The generic approach used to prepare the soil mapping protocols is applicable at a range of scales and land use applications, allowing the document to be a New Zealand Soil Mapping Protocol. Standards for different land use applications (these can be expanded as required) are established for 6 procedures (site density, site distribution, soil characterisation, soil variation, provider, and review) that are necessary components of soil mapping. Each of these procedures has 3 levels of detail (low, medium, and high) that are defined along with accompanying guidance information. This provides a framework to determine what is expected to be conducted to construct a soil map for applying to a particularly land use application. Following on from this, the work outputs can be inspected using a listing of what is expected to be provided. Finally, a self-assessment matrix allows for a summary of the level of work detail to be evaluated. The entire protocol is contained in 4 tables, with the remaining text providing detailed guidance, rationale and explanation.

Measuring runoff from a kiwifruit orchard in the Bay of Plenty

Steve Green[1], Patrick Snelgar[2], Nathan Arnold[3], Jian Liu[3], Tim Lowe[4], Mary Black[4], Brent Clothier[1]
[1]Plant & Food Research, Palmerston North, New Zealand, [2]Plant & Food Research, Te Puke, New Zealand, [3]Plant & Food Research, Havelock North, New Zealand, [4]Zespri International Ltd, Mt Maunganui, New Zealand

The Bay of Plenty Regional Council (BOPRC) are currently in the process of developing their freshwater management plan that will set limits on water abstraction and nutrient discharges to the environment. Reliable scientific data are needed to inform their policy-making process. Currently there is almost no data to confirm nutrient losses from kiwifruit orchards. To fill this knowledge gap, Zespri has contracted Plant & Food Research (PFR) to establish a series of field sites across the Bay of Plenty region to monitor the water and nutrient (N & P) balances. Two years ago, PFR installed equipment on eight orchards to measure the soil water and nutrient (N & P) losses. The orchards cover a range of different soil types (allophanic and pumice), different crop types (green and gold kiwifruit), and different management practices (organic and conventional).
The data are being used to inform and improve our modelling of the water and nutrient flows.
Recently, we added a runoff plot (8.6 x 4.1 m) to one of the sites. This paper presents results from the pilot study to quantify the overland flows. The experiments are on a commercial kiwifruit orchard near Te Puke. The soil is a Te Puke sandy loam. The site has an annual rainfall of around 1730 mm/y and so lots of runoff is expected. The soil water content is measured using TDR (time domain reflectometry) and the runoff losses are recorded using an automatic proportional sampler. Data will be presented to illustrate the complex nature of runoff events, and hint at the importance of hydrobicity. Information from our field experiments are being used by Zespri to quantify the environmental footprint associated with orchard production. The findings will help the industry to better manage irrigation and fertilizer usage in a sustainable way.

30 years of effluent land-application

Maria Jesus Gutierrez Gines[1], Charlotte Sitz[1], Sky Halford[1], Izzie Alderton[1], Vikki Ambrose[1], Jacqui Horswell[2], Sian Cass[2], Gallo Saidy[3], Dan Gerrard[3], Brett Robinson[4], Grant Northcott[5], Hamish Lowe[2]
[1]The Institute Of Environmental Science And Research Ltd., Christchurch, NZ, [2]Lowe Environmental Impact, Palmerston North, NZ, [3]Horowhenua District Council, Levin, NZ, [4]University of Canterbury, Christchurch, NZ, [5]Northcott Research Associates, Hamilton, NZ

In 1986, the Horowhenua District Council (HDC) built the first pressurised wastewater spray irrigation system in New Zealand. Wastewater from the Levin wastewater treatment plant enters a 7 ha effluent infiltration pond and the remaining volume is sprayed over 40 ha of exotic pines. The irrigation system has been delivering between 75 and 100 mm of treated wastewater (TWW) once per week over an area of 40.5 ha.
Resource consent compliance monitoring carried out by HDC indicates the 5-year average concentrations of phosphorous and nitrogen in the TWW are 5.6 mg L-1, and 39 mg L-1 respectively. This means a total phosphorous and nitrogen application to land of 250 kg P/ha/year, and 1,700 kg N/ha/year. Due to the high load of TWW application, the sandy soils and the potential preferential flow caused by pine roots, we hypothesize that P and N might have reached an equilibrium in the soil and additional applications are passing more directly to groundwater.
Ten soil cores were collected in the irrigated pine plantation, pine plantation that has never been irrigated, pasture irrigated and pasture non irrigated. Each soil core reached the water table, and samples were collected at increasing soil depths.
The preliminary results are showing an accumulation of total and available phosphorus, nitrate and ammonium, in the top soil of the irrigated plots compared with the non-irrigated. Despite the upper profile accumulation, there appears to be no significant concentration front moving towards groundwater. Vegetation plays an important role in the transport of nutrients to deeper soil horizons, with a greater mass of phosphorous and inorganic reaching the water table in the plots with pasture, compared with pine plantations.
This project is being funded by HDC, Freshwater Improvement Fund, and co-funded by ESR-Pioneer Fund.

Soil conditions and botanical composition influence pasture growth in variable landscapes

Dr Belinda Hackney[1,2], Dr Susan Orgill[1,2]
[1]NSW Department Of Primary Industries, Wagga Wagga, Australia, [2]Graham Centre for Agricultural Innovation, Wagga Wagga, Australia

Plant response to fertiliser input is dependent on both soil physicochemical properties and vegetation type. Pastures in the high rainfall zone (>650mm AAR) are often composed of multiple species grown in a highly variable landscape. However, pasture composition is rarely considered when making fertiliser decisions. The purpose of this study was to determine the effect of soil properties and botanical composition on pasture growth following the application of phosphorous (P) fertiliser to a P-deficient soils in the Central Tablelands of NSW, Australia. Seventy-two locations within a pasture field (40 ha); 38 on the northern aspect and 35 on the southern aspect were monitored for herbage production over the two-year study. For both aspects treatments were +fertiliser (single superphosphate (SSP) applied at 20kg P/ha) and -fertiliser (nil). Pasture production varied significantly with aspect, with the northern slope less productive than the south. Pasture production also varied within aspect and in some cases this difference was greater than between aspects. Despite all locations having Colwell P<20 mg/kg, only two of eight sub-regions representing 27% of the sampling locations were responsive to SSP. Pasture legume frequency and the gravel fraction (particles > 2mm) were the most important predictors of pasture production, while the number of pasture species was negatively correlated with productivity in year one. Overall, legume frequency and soil physical properties accounted for 85% (year one) and 79% (year two) of observed variation in pasture production during the study. While soil chemical properties did not have a major influence on pasture production, P availability (>20 mg/kg) and exchangeable aluminium (<17%) influenced legume frequency. Rather than relying on soil chemical analysis alone, this study suggests advisers and landholders should also consider botanical composition and soil physical characteristics when making fertiliser decisions.

Bringing the geomorphology back to modern NZ soil survey: the old “soil unit”

Sharn Hainsworth[1], Dr. Andre Eger[1], Dr. Linda Lilburne[1]
[1]Manaaki Whenua Landcare Research Limited, Palmerston North, New Zealand

S-map was designed to focus on taxonomic correlation across New Zealand soils, because soil names and soil classification below the NZSC soil subgroup level were so fragmented and of variable levels of quality and depth. This is like the approach of Marbut, chief of the US National Soils Service from 1913-1933 (Hole & Campbell, 1985).

The focus on taxonomy meant decoupling S-map soil map units from the traditional relationship between the pedogenic and geomorphogenic contexts of soil formation and consequent soil distribution. The adverse impact of this approach is that the geomorphic context of the soil sibling is an important predictor of soil distribution in the typically young, erosion prone, moderate to high relief NZ landscape, where soil distribution is primarily driven by differences in climate, slope and parent material.

Within the MBIE S-map NextGen project, a new technique is being developed and trialled that will re-introduce land systems and soil-landform models to S-map. Landsystems and soil-landform models can be combined with soil sibling entities by equating Hall (1983)’s “soil unit” with the S-map soil map unit. Factsheets will be developed directly from the S-map soil map units rather than the taxonomic approach of generating factsheets for each sibling. It is envisaged that the prototype factsheets will include trees/flow diagrams, soil-landform diagrams, geovisualistions and video clips of pedologists describing landscapes in pedogenic and geomorphogenic senses, in attempt to reach the widest possible range of audiences from a pedagogical “learning styles” perspective (Gloneck, 2013).

Hydropedology and soil-landscapes of North Curtis Island marine plain, Central Queensland, Australia

Andrew Hammond[1], Wayne Houston[3], Patrick Keleher[1], Phillip Mackenzie[1], Damon Shearer[2]
[1]School of Engineering & Technology, CQUniversity Rockhampton North Campus., Rockhampton, Australia, [2]Queensland Department of Science and Environment, Queensland National Parks Service, Nelson, Australia, [3]School of Medical and Applied Sciences, CQ University Rockhampton North Campus, Rockhampton, Australia

Curtis Island is one of the largest islands (c.58 000 hectares) within southern Great Barrier Reef World Heritage Area. Major landuse includes Curtis Island National Park and Conservation Park, agricultural and private dwellings and some of world's largest Liquified Natural Gas (LNG) export terminals.
Ecological research on NE Curtis Island has shown an extensive marine plain with salt flats and beach ridges, bounded to east by high sand dunes, is home to some critically endangered birds, the Capricorn Yellow Chat (Epthianura crocea macgregori). No studies have been undertaken to characterise the physical habitat (viz soils, geomorphology and hydropedology) where these critically endangered species reside and to present likely scenarios for Climate Change induced sea level rises.
Most of the marine plain is <5m above current sea level and is subject to influence of extra-ordinary high tides, especially those associated with tropical cyclones.
All known geospatial digital data for the marine plain and its adjacent catchments were captured and placed in an ArcGIS geodatabase. Delineation of the marine plain's catchment boundary was undertaken using Lidar imagery. Historical climatic and tidal gauge data from the nearby ports and harbours of Gladstone, Port Alma and Rosslyn Bay were acquired to show historical levels of coastal inundation, mostly those related to tropical cyclones or depressions.
Electromagnetic conductivity (DualEM 4) and Ground Penetrating Radar (GPR) transects were undertaken across the marine plain to describe the hydropedology and soil-landscapes of the marine plain and known Yellow Chat habitats. A network of piezometers is to be installed across the marine plain to measure standing water levels, salinity, pH and other hydrogeo-chemical parameters to better characterise the size, shape and distribution of the salt water freshwater interface, the soils and their relationship to known Yellow Chat distribution over a number of wet and dry annual cycles.
Keywords: Hydropedology, Curtis Island, Conductivity, endangered species, hydrogeochemistry

Competitive adsorption of silicate and phosphate by two acid Si-deficient sugarcane soils

Richard Haynes[1]
[1]Univ Queensland, Brisbane, Australia

The effects of pH on the adsorption of silicate and phosphate, either singly or in competition, by two acid soils were investigated. Both soils adsorbed 2-3 times more P than Si and adsorption isotherms at pH 5.0, 5.5, 6.0 and 6.5 showed that increasing pH greatly increased Si adsorption but decreased that of P. Silicate adsorption was very low below pH 5.0, increased rapidly up to pH 9-10 before decreasing again. Adsorption of P was at a maximum at pH 2.0, decreased slowly up to pH 7.0 and then more rapidly above pH 7.0. When Si and P were added at equimolar concentrations, the presence of P decreased Si adsorption between pH 6.0 to 8.0 while the presence of Si decreased P adsorption in the pH region 6.0 and 11. Addition of calcium silicate at rates equivalent to 300, 600, 1,200 kg Si ha-1 resulted in a progressive increase in soil pH. Separate samples of soil were treated with Ca(OH)2 to give the same pH values so that the effect of Si could be identified. The highest rate of Si (1200 kg ha-1 which gave a pH of 6.5) caused a significant decrease in P adsorption (as determined by adsorption isotherms) and an increase in resin-extractable P but the lower rates had little effect. Addition of P to the soil as calcium phosphate at rates equivalent to 30, 60 and 100 kg P ha-1 all caused a decrease in Si adsorption capacity and an increase in CaCl2-extractable Si. It was concluded that the strategy of adding Si to lower P requirements in acid soils is not likely to be effective while addition of fertilizer P may well lower Si adsorption and promote Si desorption and its increased mobility.

Development of a soil carbon monitoring framework and its implementation in hill country

Carolyn Hedley[1], Stephen McNeill[2], Pierre Roudier[1], Matteo Poggio[1], Paul Mudge[3], Louis Schipper[4]
[1]Manaaki Whenua - Landcare Research, Palmerston North, NZ, [2]Manaaki Whenua - Landcare Research, Lincoln, NZ, [3]Manaaki Whenua - Landcare Research, Hamilton, NZ, [4]University of Waikato, Hamilton, NZ

There is a global research focus on developing improved ways to monitor soil organic carbon stocks and its variations across landscapes through time, as an indicator of soil quality and to quantify any soil carbon sequestration – the latter being a direct offset of carbon dioxide emissions to the atmosphere. Soil factors (e.g. depth, stoniness, parent materials), climate, land use, topography, time and spatial position all influence the distribution and accumulation of soil carbon. The challenge, when designing a monitoring framework, is to consider the combined contribution of all these factors to the likely distribution of soil carbon stocks in the landscape to optimise selection of sampling locations, so that the likely variability of soil carbon is best sampled. Our study spatially delineated our target area (managed grasslands in hill country) and then used soil carbon (with its uncertainty, derived from a national model), position, slope, and annual rainfall, as covariates with a statistical 'balanced sampling' method to select a set of sampling locations. A power analysis using legacy data estimated that sixty locations should provide a sufficient sample size to detect a change of 1 t C/ha/year over a 5-year period, assuming a longitudinal variance of 2 t/ha/year. At each location a 20 x 20 m plot was marked out and nine soil cores collected for carbon analysis. Twelve of the 60 sites were not suitable for coring (too stony or too loose) and so three pits were sampled instead at these 12 sites. This paper will present details of this monitoring framework, soil carbon results including an analysis of short range and long range variability, and it will also provide recommendations for similar future studies.

Local scale land fragmentation on high class soils in the Waikato region

Reece B Hill[1], Haydon Jones[1], Dan Borman[1]
[1]Waikato Regional Council, Hamilton, New Zealand

Population growth in the Waikato region is resulting in the expansion of existing urban centres and rural residential areas. Unlike regions governed by a single unitary authority, the Waikato region has eleven separate local authorities (comprising one city council and ten district councils). Waikato Regional Council, through its Regional Policy Statement provides guidance for the protection of high class soils but does not have jurisdiction over the policies that govern urban and rural residential development. Regional rural subdivision indicators show that subdivision on high class soils varies across the region and through time. This paper explores the policy challenges associated with high class soils in a regional with multiple councils. We present a preliminary local scale (district and city council specific) analysis of land fragmentation on high class soils in the Waikato region.

Local policy for the protection of high class soils exhibits some commonality across the eleven local authorities in the Waikato region. Preliminary analyses indicate variable land fragmentation across local authorities and through time. Land fragmentation on high class soils generally makes up the greater proportion of land fragmented, but this varies through time, seems dependent on the proportion of high class soils in the local authority and the location of existing urban centres.

To promote consistent policy to minimise the loss of high class soils, local authorities have worked collaboratively (e.g. Futureproof) but challenges remain, especially for local authorities with urban centres (e.g. Cambridge and Matamata) surrounded by high class soils. Additionally, there is potential for proposed water quality policy to restrict the productive use of high class soils in some territorial authorities. National policy for versatile land and high class soils needs to consider these local scale challenges to ensure consistent and effective policy associated with securing versatile land and high class soils for future generations.

Contaminant losses from contrasting peat soil types and farm dairy effluent regimes: a lysimeter study

Dave Houlbrooke[1], Bill Carlson[1], Amanda Judge[1], Gina Lucci[1], Mike Sprosen[1], Justin Wyatt[2]
[1]AgResearch, Hamilton, New Zealand, [2]Waikato Regional Council, Hamilton, New Zealand

Drained peat soils represent c. 10% of the Waikato region, and are used for predominantly for pastoral dairy farming. Soil development status varies widely across farmed peats, with development status influencing peat physical and chemical properties. However, all peat has been classified as 'high risk' of contaminant losses from farm dairy effluent (FDE). The aim of this study was to compare the risk of direct contaminant losses following (FDE) application to peat soils of differing development status, under two different soil moisture regimes. Lysimeters were collected from two Waikato peat soil sites varying in development status. FDE was applied in early winter (June) and spring (September) 2017, to soils at either field capacity or 20 mm soil water deficit. Drainage was collected and analysed for mineral and organic nitrogen (N), dissolved reactive and organic phosphorous (P), E.coli, organic carbon (C) and potassium bromide. Twelve collections were made until the end of the drainage season in November 2017. The poorly developed peat soil did not transmit applied FDE through preferential flow as neither bromide or E. Coli was present in drainage leachate collections immediately following FDE application to soils at field capacity. The well-developed peat soil demonstrated strong evidence for preferential flow with high concentrations of bromide and E. Coli in drainage immediately following the application of FDE (spiked with a bromide tracer) to soils at field capacity. P loss from the poorly developed peat soil (low anion storage capacity [ASC], high C) was relatively high, and N loss was low when compared to the well-developed peat soil (high ASC, lower C). The result of this trial and 2018 drainage season data will be used to review the current risk status of peat in the soil risk framework for FDE application.

No-tillage to reduce compaction effect on soil physical quality, nitrogen loss and barley productivity

Dr. Wei Hu[1], Mike Beare[1], Craig Tregurtha[1], Richard Gillespie[1], Frank Tabley[1], Peg Gosden[1], Weiwen Qiu[1], Kathryn Lehto[1], Rebekah Tregurtha[1], Sarah Glasson[1], Steven Dellow[1], Mike George[1]
[1]Plant & Food Research, Christchurch, New Zealand

Livestock treading during winter grazing adversely affects soil physical conditions and subsequent crop/pasture production. We hypothesised that the adoption of no-tillage to establish autumn-sown forage crops may help to mitigate these adverse effects of winter grazing. To test this hypothesis, a forage oat crop was established on a silt loam soil at Lincoln in March 2016 using no-tillage (NT) and intensive tillage (IT). Following removal (simulated grazing) of the oat crop in July, five compaction levels (0, 147, 183, 220, and 261 kPa) were used to simulate different grazing intensities. Two urea-N treatments (present (+U) or absent (-U) of 400 kg N ha-1) between sub-plots were used to evaluate the effects of urine patches. Results showed that compaction significantly degraded soil physical quality. Compared with IT, adoption of NT for forage crop establishment mitigated the effects of treading on soil physical quality, but the benefits of NT were only short-lived due to natural recovery and the use of shallow tillage for subsequent barley cultivation. The use of NT to establish the forage oat crop facilitated the early growth of the barley crop, but it did not significantly affect barley production at final harvest or nitrogen losses. Nevertheless, NT has benefits for forage crop systems by reducing fuel consumption and soil compaction. Urinary N input promoted vegetative growth of barley in the early stages of growth, but negatively affected its reproductive growth at the late stage which resulted in significantly less grain yield for +U plots. Urinary N input also resulted in more N loss during the barley phase. Therefore, urinary N input should be considered when applying fertiliser N to subsequent crops. There was some evidence that moderate levels of compaction (180–220 kPa) may benefit barley production and reduce N losses from forage crops systems using NT establishment practices.

Considering the value proposition of variable rate N fertiliser

Adrian Hunt[1], Jo Sharp[1], Paul Johnstone[1], Searle Bruce[1]
[1]*Plant & Food Research*

Advances in fertiliser application technology make it feasible to apply nutrients at variable rates, relative to soil properties and potential crop demand at a sub field scale. However for industry to move beyond flat rate applications a clear understanding of the value proposition underpinning variable rate is needed to justify the additional inputs of time and capital that would be required in increasing the complexity of crop management.

We utilised grid soil sampling to gain an understanding of the spatial distribution of soil mineral and mineralisable nitrogen (N) across a selection of five representative cropping fields. The data was used to test different N management approaches by predicting crop yield, gross margins and residual N outcomes using the APSIM Next Generation modelling framework and maize grain as the case study system. Management approaches included uniform rate without considering measured soil N properties, uniform rate adjusted for field mean measured soil N properties and spatially-adjusted N rate based on measured soil N properties.

Our results from this work will be presented to clarify the potential productivity, economic and environmental benefits of using soil properties to inform the application of N in both irrigated and un-irrigated systems.

Molecular approaches to identify benign denitrification in shallow groundwaters.

Neha Jha[1], Ranvir Singh[1], Marcela Gonzalez[1], Andrew McMillan[2]
[1]*Institute of Agriculture and Environment, Massey University, Palmerston North, New Zealand ,* [2]*Manaaki Whenua-Landcare Research, Palmerston North, New Zealand*

Water quality is of increasing concern in sensitive agricultural catchments across New Zealand landscape. Nitrate (NO_3^-) leached from pastoral grazing and other intensive land uses is implicated as a key contaminant in the deterioration of surface and ground water quality. However, leached NO_3^- if encounter suitable conditions can be attenuated (reduced) by denitrification in subsurface environment before reaching surface waters. Microbially-mediated denitrification is an important biological process, which converts the active nitrogen oxides (NO_3^- and NO_2^-), with the help of a set of four reductase enzymes back to inert dinitrogen (N_2) and thereby completing the N-cycle. Environmental benefit of subsurface denitrification, however, may be limited if subsurface denitrification is incomplete and the terminal product of NO_3^- reduction is N_2O (a harmful greenhouse gas) rather than N_2 (an inert and harmless gas making up 78% of the atmosphere).

Using gas chromatography for dissolved N_2O, hydro-chemical analyses, and quantitative PCR (qPCR) on three denitrifier functional genes (nirS, nirK and nosZ) we assess the factors linked to subsurface denitrification in shallow groundwater samples from 6 pastoral farms located in various hydrogeological settings in Manawatu and Rangitikei River catchments, located in lower North Island of New Zealand.

We found lower dissolved N_2O and higher denitrifier gene abundances in the groundwater samples collected from anoxic (reducing) sites as compared with the groundwater samples collected from oxic (non-reducing) sites. This paper will present a detailed analysis of monthly collected (over a period of 12 months) shallow groundwater samples, with a focus on assessing the potential of measuring abundance of denitrifier genes (in particular nosZ) as a rapid and cost-effective tool for a qualitative measure of complete NO_3^- reduction in shallow groundwaters in New Zealand environment.

Adsorption-desorption of glyphosate in New Zealand soils

Jesus Adalberto Jimenez Torres[1], Christopher Anderson[1], Paramsothy Jeyakumar[1]
[1]*Massey University, Palmerston North, New Zealand*

Glyphosate is the most used biodegradable herbicide in agricultural system throughout the world. The extended use of glyphosate in the farmlands have raised concerns about its possible residual effect in soil and water. Aminomethyl-phosphonic acid (AMPA) is the main degradation metabolite of glyphosate, and it has been detected in the environment. A study was conducted to determine the adsorption-desorption capacity of glyphosate on three contrasting soils; Pallic, Brown and Allophanic soils in New Zealand. Soils were saturated with 1 mg/L of glyphosate, at a ratio of soil:glyphosate 1:10 (w/v). Residual glyphosate in the solution-phase was measured. The glyphosate held in the solid-phase was extracted with 20 mL of 0.03M Na3PO4 and 0.01M C6H5Na3O7.2H2O at alkaline condition (pH=12.5); and the alkaline extractable glyphosate was also measured. The glyphosate concentration was analysed by RP-HPLC. The glyphosate found in the solution-phase after saturation of the Pallic soil was 9.47%, while in Brown and Allophanic soils were 0.09 and 0.04%, respectively. Therefore, Brown and Allophanic soils possess higher glyphosate retention capacity; and suggesting higher glyphosate solubilisation rate in Pallic soil. The extractable glyphosate levels found in Pallic and Brown soils were 61.6 and 65.5%, respectively; the glyphosate extracted from Allophanic soil was 42.8%; thus, the higher aluminium content of the Allophanic soil may influence on the glyphosate extraction efficiency, holding about 20% more glyphosate than the Pallic and Brown soils. These results can help to elucidate the stability of glyphosate in New Zealand soils.

Loss of versatile land available for production

Haydon Jones[1], Reece Hill[1], Fiona Curran-Cournane[2], Dan Borman[1]
[1]*Waikato Regional Council,* [2]*Auckland Council*

Protecting New Zealand's versatile land and high class soils has been a point of concern raised by the soil science community for many years. There is little doubt that this resource is continuing to be lost to urban and rural residential expansion. With forecast population growth, further demand for land to meet housing needs and the on-going expansion of residential areas is likely.

Developing mechanisms to retain versatile land and high class soils is essential to ensuring future access to the natural capital and services of this finite resource. Postulated mechanisms include zoning (e.g. Auckland Unitary Plan), developing a National Policy Statement, and establishing national food security zones. Momentum to protect this resource has recently increased, with the Minister for the Environment, the Honourable David Parker requesting the development of a National Policy Statement for versatile land and high class soils. A strong evidence base will be required to inform its progress and development, however, nationally consistent and up-to-date quantitative and qualitative data have been generally lacking.

This paper presents new methods and preliminary analyses undertaken to explore the extent of urban and rural residential expansion since 2001, and the associated loss of land available for primary production, in the Auckland and Waikato regions. For these analyses, urban and rural residential areas were defined as parcel size categories 0 to 0.50 ha and 0.51 to 2 ha, respectively, both with a dwelling.

Our analyses suggest that urban and rural residential expansion is an important contributor to the loss of land available for primary production in the Auckland and Waikato regions and the land lost from production is predominantly the more versatile land. Similar analyses are underway nationally and need to be considered as part of developing a national approach to securing versatile land and high class soils for future generations.

Are soil carbon stocks controlled by a soil's capacity to protect carbon from decomposition?

Miko Kirschbaum[1], Gabriel Moinet[1], Carolyn Hedley[1], Michael Beare[2], Sam McNally[2], Donna Giltrap[1], Liyin Liang[1]

[1]Lancare Research - Manaaki Whenua, Palmerston North, New Zealand, [2]Plant & Food Research, Lincoln, New Zealand

GGreenhouse gas emissions can be off-set by increasing soil organic carbon (SOC), but the factors controlling changes in SOC storage must be understood to identify suitable management practices. Soils differ in their ability to stabilise SOC, but do soils have a maximum capacity to stabilise carbon, or does stabilisation simply act to reduce turn-over rates without limits? Here, we use observations from two specific NZ sites, and from national soils data to gain insights into the controls of SOC stabilisation. They showed:

1. When other factors such as climate, soil fertility, and pasture management were the same, SOC was linearly correlated with soil specific surface area (SSA).
2. At each soil depth, SOC and SSA were linearly related, with the slopes of the relationships decreasing with depth.
3. Small intercept values at zero SSA implied that SOC was mostly protected by the soil matrix rather than biochemically, that mineral surface area was the functionally relevant measure of stabilisation capacity, and that its effectiveness was independent of carbon input rates.

We analysed the national soils data for evidence of a maximum stabilisation capacity. If SOC was limited by maximum stabilisation capacity it should result in a skewed distribution of SOC around mean values. Some points could be much lower than the maximum stabilisation capacity, but points could not exceed that maximum capacity. SOC in the national data set, however, was normally distributed, thus being inconsistent with maximum stabilisation capacity as a SOC limitation.

Instead, our analysis suggested that protected SOC could be described as:

Cp, = Cin S / f(T, W, …), where Cin is the carbon input rate, S is SSA, and f(T, W, …) is a SOC turn-over rate depending on temperature, soil moisture and other factors.

Key words: carbon saturation, clay, moisture factor, soil organic carbon, surface area.

Sustainable nutrient management system for taro growers in Taveuni, Fiji

Rohit Lal[1]

[1]Student At Massey University , Palmerston North, New zealand

Abstract

Taro (Colocasiaesculenta) is a major component of socio-cultural, dietary and economic livelihood of Pacific Island countries. Fiji's total taro exports reached a peak in 2007 of approximately 12,000 tonnes, but declined over subsequent years to about half this level. About two thirds of Fiji's taro export crop is grown on the island of Taveuni. A survey of soil fertilityand taro grower practices on Taveuni,revealed that yields and soil fertility status were low. Generally, 76% of the growers had soil Olsen P levels of below 10 mg/kg.

Field experiments were conducted in three different locations in Taveuni to determine the optimum fertiliser strategies to improve taro productivity. Fertiliser rates of 200kg N/ha, 120 kg P/ha, 200 kg K/ha and 82 kg S/ha achieved average taro com yields of 15 t/ha ($P<0.05$), compared to only 6.2t/ha for the control no fertiliser treatment. In addition, maximum tarosucker production was achieved with N rates of 280 kg N/ha. In more recent years, on-going shortages of taro suckers, used for planting new crops, have resulted in sucker costs being maintained at up to three times the pre-cyclone Winston levels. This study has demonstrated how growers can optimise taro yields and increase the supply of planting material through improved fertiliser management.

Soil Matters

Annabel Langbein
Author, Publisher and Celebrity Cook

Celebrating the food we grow is central to everything I do. The chain of goodness begins with healthy soil and finishes with healthy animals, healthy people and healthy environments.

The better the soil, the better the grass, the better the milk. The better quality the milk, the better the yoghurt, cheese, and butter. Ninety five percent of we eat relies on the earth and by looking after our soils we have the ability to promote good health in our populations..

Increasingly our soils are under threat- from urban development, agricultural practices and industry. Degraded soils lack the ability to cope with extreme weather events that are increasingly becoming the norm.

The carbon cycle that enabled life on earth to develop over 500 million years ago is now out of balance. With an excess of carbon in our atmosphere we are now living the consquences of climate change.

Regenerative practices to build retain and promote healthy soils have to be one the best responses to climate change. By doing this we can reduce the carbon in the atmosphere and get it back into the earth. The health of our soils is at the heart of our continued prosperity as a species.

I started making my own compost when I was fourteen, and I also studied horticulture at Lincoln university, but for all this, t's only in recent years that I have started to understand that creating healthy strong soils that will support maximum photosynthesis and enable the uptake of important nutrients takes a lot more than compost.

Join me as I take you through the journey of my garden and explain why soil MATTERS.

Hydropedology and salinity in Hedlow Creek Catchment

Andrew Hammond[1], Patrick Keleher[1], **Sunita Lata[1]**
[1]School of Engineering and Technology, CQUniversity, Rockhampton, Australia

The study area, Hedlow Creek Catchment is located in central Queensland approximately 40 kilometres north of Rockhampton. It is situated within the Lower Fitzroy River Catchment and forms part of the Fitzroy River Basin. The aim of the research project is to undertake a desktop audit of the previous studies to form a baseline understanding of the relationship between the hydro-pedological attributes and dryland salinity within the catchment. Previous studies show that Hedlow Creek Catchment has undergone a significant landuse change since 1800s. Currently the catchment is predominantly used for grazing purposes with sown pastures and horticultural production. The historical clearing events and subsequent changes in land use has caused salinity issues within the catchment. Salinity study undertaken by Department of Industry, Science and Resources identified 38 salinity occurrences within the Fitzroy River Catchment, of which 13 occurrences of salt affected areas (total 1156.4 hectares) were within the Hedlow Creek Catchment. Previous salinity studies undertaken in the catchment included re-vegetation trials using native vegetation. However, the cause/process of the salinity issues within this catchment has not been investigated and as such remains poorly understood. The audit will provide an overview of the soil landscape and hydrologic processes enabling better interpretation of the cause of dryland salinity issues within the catchment. It will discern the soil pedological properties capable of influencing hydrological fluxes. Methodologies for this audit include desktop review of existing studies and undertaking GIS mapping of the hydro-pedological attributes of the catchment. Existing Queensland Government spatial data is currently being used to map the hydro-pedological attributes of the catchment. The characterisation of the hydro-pedological aspects will be related to salt affected areas within the catchment. This characterisation will be later used in the research to predict and identify areas most susceptible to dryland salinity.
The data collected during the audit will be used to describe the pedological units, affected by the hydrological regimes and identify areas likely to be impacted by dryland salinity in future.

Application of soil C stabilisation capacity methodology for soil quality monitoring

Erin Lawrence-Smith[1], Sam McNally[1], Michael Beare[1], Denis Curtin[1], Kathryn Lehto[1]
[1]*Plant & Food Research, Lincoln, New Zealand*

Soil carbon (C) is a key soil property and plays an important role in many ecosystem services. It is generally accepted that soils have a finite ability to store stable C, known as the C stabilisation capacity. This allows the current C content of soil to be expressed as a function of its C stabilisation capacity. Determining whether a soil is near this stabilisation capacity is important in identifying soils that a) have lost significant quantities of soil C, b) are vulnerable to C loss or c) have the ability to gain additional soil C. Interpreting soil C data in this context may influence future land management decisions. We applied a previously published methodology to estimate the C stabilisation capacity and saturation deficit of 0-15 cm soils in New Zealand to soils collected from 0-10 cm; the sample depth most commonly used for regional State-of-Environment monitoring. The application of this method for soil quality monitoring will be discussed. Our 0-10 cm soil analysis found cropping soils had saturation deficits 1 to 3 times greater than the deficit of pasture soils. Furthermore, Allophanic soils had higher mean soil C saturation deficits than other soil orders despite having the highest concentrations of C.

Nitrogen footprint of Taupo Beef through the life cycle to consumers

Stewart Ledgard[1], Shelley Falconer[1], Sandra Payen[1], John Rendell[1], Sharon Barton[2], Mike Barton[2]
[1]*Agresearch, , New Zealand,* [2]*Farmer, Turangi, New Zealand*

Farms in the Lake Taupo catchment of New Zealand have a farm-specific nitrogen (N) leaching limit per hectare. A beef cattle finishing farm in the catchment was used as a case study to compare optimised scenarios with and without N constraints and with flexible supply to meat processing companies or a requirement for regular supply to restaurants based on a premium price for beef with a low N footprint. Scenario analyses included evaluation of sourcing surplus young beef cattle from breeding farms or from dairy farms. A life cycle assessment method was used to estimate all reactive N emissions through the life cycle of beef. Leaching of N from the finishing farm was <20 kg N/ha/year from N-constrained scenarios and 43 kg N/ha/year with no N constraint. Profitability decreased with N constraints and with regular beef supply requirements, which could be countered by a price premium. The N footprint from beef production ranged from 95 to 156 g N/kg meat, being least from the N-constrained scenarios. It was lower from dairy-derived beef and higher with regular beef supply requirements. The farm stage dominated the life-cycle N footprint (78% of total emissions) with the only other significant contributor being the final waste (sewage) stage at 21% of the total, based on a traditional urban waste water treatment system. Analyses indicated that the Taupo town sewage system of land application to pasture for silage production and feeding back to cattle can further decrease the N footprint over the life cycle of beef.

White lupin roots forage and mobilize phosphorus in a nutrient-poor soil

Zicheng Yi[1], **Niklas Lehto[1]**, Brett Robinson[2]
[1]Lincoln University, Lincoln, New Zealand, [2]University of Canterbury, Christchurch, New Zealand

The bioavailability of phosphorus (P) is a key factor limiting plant growth in many agricultural soils. Some plant species are thought to overcome nutrient limitation by employing root foraging behaviour. This can include proliferating roots preferentially in areas with more available nutrients in heterogeneous soil environments and employing mechanisms that mobilize nutrients from otherwise inaccessible pools. Our aim was to investigate the extent to which White lupin (Lupinus albus L.) can employ root foraging behaviour to overcome P limitation in a nutrient-poor soil.

We amended subsamples of a well characterized nutrient-poor soil with ground reactive phosphate rock (RPR) and established four treatments where the RPR-amended soil was distributed homogeneously, and heterogeneously as discrete well-defined patches in the un-amended soil, in rhizoboxes. We grew White lupin in the rhizoboxes under a controlled environment, and recorded the root distribution at the sampling plane of the rhizobox. After four weeks of growth, we used diffusive gradients in thin-films (DGT) to measure the distribution of soil P mobilization across a 14×14 cm area, covering root-soil interfaces and bulk soil in select rhizoboxes. We also quantified the root distribution in the rhizoboxes, as well as the root and shoot biomass and elemental composition.

The plant biomass was higher in the RPR-amended soils than in the un-amended soil control ($p<0.05$), however the distribution of the P in the rhizoboxes did not result in differences in biomass ($p<0.05$). We observed preferential root proliferation in the patches of soils that had been amended with RPR, and that P mobilization was consistently higher near the roots than in the bulk soil. Our results show that White lupin roots can forage for P in soils to utilize otherwise inaccessible pools of the nutrient. This behaviour could be exploited to achieve more efficient nutrient use on agricultural soils.

Quantifying nutrient attenuation performance of Detainment Bunds in the Lake Rotorua Catchment: Preliminary data

John Paterson[3], **Brian Levine[1]**, Lucy Burkitt[1], David Horne[1], Chris Tanner[2], Leo Condron[3]
[1]Massey University, Palmerston North, New Zealand, [2]NIWA, Hamilton, New Zealand, [3]Lincoln University, Lincoln, New Zealand, [3]Phosphorus Mitigation Project Inc

Identifying and implementing appropriate strategies that manage nutrient loading into Lake Rotorua is a priority of the Bay of Plenty Regional Council (BoPRC) and local stakeholders aiming to achieve goals set in the Lake Rotorua Nutrient Management Plan. Lake Rotorua, located within the BoPRC jurisdiction, provides valuable ecosystem services that are at risk due to water quality degradation. Nitrogen and phosphorus (P) delivered by surface runoff from intensive pastoral agriculture have been identified as main contributors to Lake Rotorua eutrophication. Strategies that address P loss from agriculture during storm periods offer opportunities for effective remediation. Detainment bunds (DBs), which are low, earthen dams, capable of temporarily ponding large quantities of water delivered by ephemeral streams generated by intense rain events, are being investigated as a potential remediation strategy. Prior research on DBs serve as a proof of concept, although there is no quantitative data available on DB performance under New Zealand conditions. This study reports preliminary data on loads of total N and P, dissolved reactive P, nitrate-N, ammonium and suspended sediments, released from temporary ponds compared to loads delivered to the pond in surface runoff from multiple storm events and DB locations within the Lake Rotorua catchment. The results suggest that the DB strategy may be an effective tool to add to the options available to pastoral farmers attempting to decrease nutrients and sediment transported from their farm by surface runoff, in efforts to meet regulatory targets aimed at restoring water quality in the Lake Rotorua catchment. Quantification of DB performance is necessary for decision makers interested in implementing DBs locally, promoting the strategy at a national scale, and developing a nutrient attenuation credit program using nutrient management models such as OVERSEER®.

Root exudates enhance soil respiration rates and the ratios of N2/N2O emissions

Yuan Li[1,2], Professor Tim Clough[1], Dr. David Whitehead[2]
[1]Lincoln University, Lincoln, New Zealand, [2]Manaaki Whenua – Landcare Research, Lincoln, New Zealand

Soil respiration rate (Rs), soil C priming effect (PE) and gasous N emissions (nitrous oxide N2O and dinitrogen N2) vary with root exudate composition and soil water content but the processes are not known. Repacked soil cores were held at three levels of soil matric potential (ψ, -3, -5 and -7 kPa), and received daily additions of 13C labelled-synthetic root exudates (acetate, butyrate, glucose, water control) for 14 days. A labelled source of N as KNO3-15N was supplied to treatments at the start of the experiment. The highest Rs of 2.64 ± 0.32 µmol m−2 s−1 (mean ± standard error, n = 4) occurred for soil held at -7 kPa and supplied with butyrate,. When soil was treated with glucose, Rs tended to increase more rapidly than rates for soils with added acetate or butyrate. On day 3, the relative PE under the acetate and butyrate treatments was higher than that under glucose regardless of ψ. By day 14, the relative PE under acetate was higher than that under butyrate or glucose. N2O emissions on day 4 (4 ± 2 mg N m−2 h−1) were highest for soil with added glucose and held at -3 kPa. On day 3, higher N2:N2O ratios occurred for soils treated with acetate and butyrate compared with those when glucose was added regardless of ψ,. We conclude that additions of glucose and OA enhanced Rs and N2O emissions. Rs was similar for soils treated with glucose or OA, but the PE induced by OA was higher than for glucose. Organic acids led to increased N2:N2O ratios compared with those for addition of glucose substrate. The impact of ψ on Rs was more important than the effects of exudate type. Our findings highlight the significance of root exudates on greenhouse gas emisisns from soil.

Nitrous oxide fluxes determined by eddy covariance measurements from intensively grazed pastures: patterns and controls

Liyin Liang[1,2], David Campbell[2], Aaron Wall[2], Louis Schipper[2]
[1]Manaaki Whenua - Landcare Research, Palmerston North, New Zealand, [2]University of Waikato, Hamilton, New Zealand

Climate models project enhanced temperature and water stress scenarios in future climate and environmental changes could affect ecosystem metabolic processes, e.g., greenhouse gas (GHG) exchanges between the atmosphere and the biosphere, especially in the agroecosystem. In this study, we provided continuous measurements on nitrous oxide (N2O) fluxes, a prominent greenhouse gas, from a grazed pasture in New Zealand using Eddy Covariance (EC) techniques in combination with a quantum cascade laser (QCL). Measurements consistently identified significant N2O emission pulses to appear after rainfall associated with grazing events in summer. We observed a clear seasonal pattern of N2O emissions and found higher accumulated rates of N2O fluxes in autumn than in summer or winter. The data identified an optimum soil moisture/temperature zone that favours maximal N2O emissions, demonstrating maximum N2O fluxes at ~70% water-filled pore space (WFPS) and moderate soil temperatures. Clear diurnal flux patterns emerged in both pulse and background flux periods, suggesting soil temperature could influence soil microbial processes at sub-daily scales. The continuous measurements of N2O fluxes from EC provided great potential to quantify the integrated N2O emissions over a range of spatial and temporal scales. Advances in the understanding of paddock scale N2O emissions are of an urgent needs to reveal the controls of agricultural GHG emissions, particularly aiming to provide accurate estimates in national GHG inventories.

The land use suitability concept: a Southland case study

Linda Lilburne[1], Ton Snelder[2], Doug Booker[3], Amy Whitehead[3], Simon Harris[2], Scott Larned[3], Annette Semadeni-Davies[3]

[1]Manaaki Whenua - Landcare Research, Lincoln, New Zealand, [2]LWP, Lyttelton, New Zealand, [3]NIWA, Christchurch, New Zealand

The Land Use Suitability (LUS) concept provides a framework for assessing the suitability of land for primary production that accounts for connections between land use and economic, environmental, social and cultural impacts. The framework aims to inform decision-makers with spatially-explicit information describing various consequences of land use choices. This assessment of 'Productivity within Environmental Constraints' (PEC) is one example of the LUS concept. PEC evaluates the suitability of land for sustained productivity subject to environmental constraints, as defined by water quality targets. We describe the implementation of a PEC assessment of suitability of land for sustained production with constraints associated with nitrogen fluxes across a heterogenous land-water system. A modelled representation of a land-water system is used to calculate three indicators: productive potential; relative contribution; and pressure. Several methods of combining these indicators into a single map of suitability are contrasted. This implementation of a PEC assessment highlighted that the LUS concept of suitability of land is not an intrinsic and static property of a land parcel but is dependent on the wider environment (the catchment in our PEC application) and varies with normative decisions concerning the acceptability of environmental effects, assumptions about catchment land use, and choices concerning environmental targets and trade-offs between production and the environment.

The impacts of delivering credence attributes of livestock products

Gina Lucci[1], Stewart Ledgard[1], Wei Yang[2], Spring Zhou[3], Grant Rennie[1], Geoff Mercer[1], Carel Bezuidenhout[4]

[1]AgResearch, Hamiton, New Zealand, [2]AgResearch, Lincoln, New Zealand, [3]School of Engineering and Advanced Technology, Massey University, , New Zealand, [4]SCION, Rotorua, New Zealand

One strategy to increase agricultural profitability is to capture more value by delivering credence attributes (CAs) for which consumers have demonstrated a willingness to pay (WTP). Demonstrating this additional value could stimulate changes on farm that have positive environmental benefits. However, what has not been investigated is what practical changes delivering CAs will require on farm, what it will cost, and the overall impact it will have on production and on the environment.

We have modelled dairy farming systems to deliver pure "grass-fed" products; and dairy farming, and sheep and beef, systems to deliver "carbon neutral" products. These CAs were identified at a multi-stakeholder workshop attended by farmers and rural professionals. Dairy farm systems were based on surveyed averages for Waikato and in Southland, while the sheep and beef farm was based on an average Class 4 North Island hill farm. The base and CA farms were modelled in FARMAX and OVERSEER® Nutrient Budgets. The effects of uncertainty of the price premium on farm profitability were modelled using a Monte Carlo simulation. Revenue distribution along the value chain was estimated considering the interaction of businesses.

Delivering grass-fed or carbon neutral dairy has the potential to reduce nitrogen (N) leaching losses by 19 - 42%, and reduce greenhouse gas (GHG) emissions by 0 - 31%. However, production is also reduced and actions to offset production losses on farm (e.g. through increased use of fertiliser N) quickly erode the reduction in N loss and GHG emissions. Price premiums of 5 - 65% are required to restore profitability to the same level as the base farm scenarios. Yet, the proportion of value captured on farm, with respect to that of the whole value chain, remains low (ca. 13%) when delivering credence attributes.

Nitrous oxide emissions from beef and dairy cattle excreta deposited on grazed pastoral hill lands

Dr Jiafa Luo[1], Dr Surinder Saggar[2], Dr Tony ver der Weerden[3], Dr Cecile de Klein[3], Stuart Lindsey[1], Alison Rutherford[3], Bill Carlson[1], Bridget Wise[1], Peter Berben[2], Thilak Palmada[2], Amanda Judge[1]
[1]Agresearch Ruakura, Hamilton, New Zealand, [2]Manaaki Whenua – Landcare Research, Palmerston North, New Zealand, [3]AgResearch Invermay, Mosgiel, New Zealand

Nitrous oxide (N2O) emissions and emission factors (EF3; percentage of excreta nitrogen emitted as N2O) from sheep, beef- and dairy-cattle excreta can vary with hill land slope. Therefore, separation of EF3 based on slope may result in a more accurate inventory of national N2O emissions. Field trials were conducted in the Northland, Manawatu, Waikato and Otago regions of New Zealand on dairy-grazed and sheep & beef-grazed hill land. N2O emissions were measured from low (0 – 12°) and medium (13 – 24°) sloping land, both from control plots (background emissions) and from plots receiving dairy and beef cattle urine and dung in late autumn. Application of cattle urine or dung increased N2O emissions compared to background emissions in most cases with different magnitudes of increase between excreta types, slope classes or regions. However, there was no statistically significant difference between EF3 values for beef and dairy cattle excreta (urine or dung) on either low or medium slopes. This was the case for each individual region and also when the data from the Northland, Waikato and Manawatu regions were combined. These findings suggest that N2O EF3 values for excretal inputs on established dairy hill land low and medium slopes are similar. However, our results confirm the findings of previous New Zealand studies that hill land under a sheep & beef grazing management regime has lower EF3 for deposited excreta on medium slope land than on the low slope land. Our measured country-specific variations in EF3 can be used to improve the accuracy and transparency of farm-, regional- and national-scale N2O inventories. These findings could also help farmers and policy-makers in devising strategies to reducing N2O emissions by targeting mitigation technologies to areas and sources with high EF3 (N2O hotspots) and encouraging hill land livestock farming with animal species with low EF3.

Using the SedNetNZ model as a policy planning tool in Hawke's Bay

Barry Lynch[1], Les Basher[2], Mary-Anne Baker[1]
[1]Hawke's Bay Regional Council, Napier, New Zealand,
[2]Manaaki Whenua - Landcare Reserach, Nelson, New Zealand

Sediment is a major issue in many regions across New Zealand. Hawke's Bay Regional Council (HBRC) is currently tackling the issue through policy and a plan change informed by the SedNetNZ model. The area concerned covers 350,000 ha.
SedNetNZ is an erosion model that predicts the generation and transport of sediment through river networks. The model provides estimates of long term average annual sediment load (t yr-1) and yield (t km-2yr-1). It provides estimates of sediment load generated by different erosion processes and sediment deposition on floodplains. This allows improved targeting of erosion mitigation and analysis of the linkages between upstream sediment generation and downstream sediment loading. It is also highly suited for scenario analysis of changes in land management and implementation of erosion mitigation practices.
For example in the targeted plan change catchments it was estimated the current sediment load from hillslope erosion processes is 989,553 t yr–1 but this could be reduced to 761,475 t yr–1 (23%) by implementing farm plans on the 100 farms with the greatest area of highly erodible land.
Hawkes Bay Regional Council is using the SedNetNZ model to help identify priority areas of erosion/ sediment production where water quality or deposited sediment is a problem. This information is related back to stakeholder/farmer groups involved in the land and water plan change processes. It has allowed Council to supply stakeholders with estimates of the scale of the sediment issue, estimates of costs associated with reducing sediment and possible ways this may be achieved. The modelling is also helping direct policy discussions around setting sediment reduction targets and whether that can be achieved through non-regulatory methods.
SedNetNZ is proving to be an essential tool in developing freshwater management plans especially in relation to the improvement of fresh and coastal water bodies being adversely affected by sediment.

Changes in soil carbon in hill country under contrasting phosphorus fertiliser and sheep stocking rate

Alec Mackay[1], Ronaldo Vibart[1]
[1]*AgResearch Grasslands, Palmerston North, New Zealand*

Given the significance of soil as a reservoir of carbon (C) within the global C cycle, information on how temperate grazing land management affects soil C stocks is becoming increasingly important. We examined soil C stocks over time as part of the long-term phosphorus (P) fertiliser and sheep grazing study at Ballantrae, southern Hawke's Bay. Farmlet treatments received either 125 kg ha-1 y-1 of single superphosphate (SSP) from 1975-1979 and none since (LFNF); the same amount of SSP applied as LFNF from 1975-1979, but 125 kg SSP ha-1 y-1 since 1980 (LFLF); or 625 kg ha-1 y-1 of SSP applied from 1975-1979 and 375 kg SSP ha-1 y-1 since 1980 (HFHF). Except for differences in the upper soil layer (0-7.5 cm) in 2003. with C stocks increasing from 30.9 to 32.5 and 35.1 t C ha-1 on the LFNF, LFLF and HFHF farmlets, respectively, management had no influence on soil C stocks at greater depths (0-15 and 0-30 cm) in 2003 or in the 0-7.5 and 0-15 cm depths in 2014. Adding these findings to earlier measures of soil C stocks from the same farmlets provides a time series (1972-2014) that supports the view that soil C stock are stable under permanent pasture and not influenced by management. In sharp contrast slope was a significant factor influencing soil C stocks, as was aspect. The effect of slope appears more pronounced on the HFHF farmlet with C stocks higher on the Low slope. It is plausible that the high P fertiliser inputs enable the differences in potential pasture production across the three slope classes in the HFHF farmlet to be expressed and simultaneously the higher sheep numbers in the HFHF farmlet redistributed more C through animal transfer in dung from the High and Medium to the Low slope position. Both slope and aspect as a consequence need to be factored into sampling regimes monitoring soil C stocks in hill country. They also need to be included in models used to explore changes in soil C stocks under temperate pastures, if we are to advance our understanding of the factors influencing the long-term changes in soil C stocks in hill soils. The modelling approach adopted in this study and reported in this paper captures the influence of slope and aspect on both primary production and on the animals grazing and camping behaviours.

Using catch crops to mitigate nitrate leaching following autumn grazed fodder beet in Waikato

Brendon Malcolm[1], John de Ruiter[1], Dawn Dalley[2], Paul Johnstone[3], Steven Dellow[1], Nathan Arnold[3], Deanne Waugh[4]
[1]*The New Zealand Institute for Plant & Food Research, Lincoln, Canterbury, New Zealand,* [2]*DairyNZ Ltd, Lincoln, Canterbury, New Zealand,* [3]*The New Zealand Institute for Plant & Food Research, Hastings, Hawke's Bay, New Zealand,* [4]*DairyNZ Ltd, Hamilton, Waikato, New Zealand*

Autumn grazing of high yielding forage crops such as fodder beet is increasing in popularity in many parts of the North Island. However, large quantities of urinary nitrogen (N) is deposited onto bare soil during grazing, enhancing the risk of N leaching.

A rigorous soil sampling strategy was used to determine the effect of oats or Italian ryegrass catch crops to reduce the amount of soil N at risk of leaching after fodder beet grazing by lactating dairy cows in early April 2017 in Waikato. Three replicate paddocks were used, with half of each paddock supporting cows on either high (40% of diet, with pasture) or low (25% of diet, with pasture) fodder beet allocations. In early May, each half was further divided and sown into either oats or Italian ryegrass, with a 5 m fallow control strip between the crops. Bimonthly soil samples were taken for mineral N determination at 30 cm depth increments down to 90 cm depth in each plot until oats were harvested for silage in October 2017. Italian ryegrass was rotationally grazed and herbage samples were obtained for both oats and Italian ryegrass on a monthly basis from July to determine dry matter (DM) production and N removal by the crops.

Results showed both Italian ryegrass and oats reduced soil mineral N between 0 and 90 cm depth by 28–40% by August, and 53–56% by October, compared to a fallow control. The greatest reductions were observed beneath oats (particularly during the cooler months), resulting largely from higher DM yields and a greater amount of N captured by the oats. We conclude that sowing an oat catch crop after forage crop grazing in late autumn offers greater benefits than Italian ryegrass in terms of reduced risk of N leaching, without compromising annual biomass production.

Soil and tree-stem N2O fluxes of a large-scale oil palm plantation in Sumatra, Indonesia

Amanda Matson[1,2], Marife D. Corre[2], Aiyen Tjoa[3], Mohammed Damris[4], Edzo Veldkamp[2]
[1]Scion, Rotorua, New Zealand, [2]University of Goettingen, Goettingen, Germany, [3]Tadulako University, Palu, Indonesia, [4]Jambi University, Jambi, Indonesia

Oil palm plantations cover large areas of Southeast Asia, with Indonesia and Malaysia currently the principal oil palm producers worldwide. As compared to smallholder plantations, large-scale oil palm plantations have the potential for much higher soil nitrous oxide (N2O) fluxes, but measurements from large-scale plantations are scarce, especially measurements that include soil-mediated tree-stem N2O fluxes. We quantified N2O fluxes from the soil and tree stems of a large-scale oil palm plantation in Sumatra, Indonesia. Soil and tree-stem fluxes were measured bi-monthly for one year (2015-2016), using vented, static chambers with permanent bases (soil) and removable stem chambers (palm stem). The source of tree-stem N2O emissions was confirmed using a nitrogen (15N) tracer. Tree-stem N2O emissions from the twelve measurement trees were strongly correlated with soil N2O concentrations ($R = 0.85$; $P < 0.01$). The 15N tracer showed that tree-stem N2O fluxes were a direct result of N fertilizer application to the soil. The seasonal pattern showed strong response of both soil and tree-stem fluxes to soil N amendments and N2O fluxes were positively related to soil water-filled pore space across the 34 sampling dates ($R = 0.67$; $P < 0.01$ and $R = 0.71$; $P < 0.01$ for soil and tree stems respectively). Annual N2O fluxes were 4.88 - 5.27 kg N2O-N ha-1 yr-1, and oil palm stems contributed 2-8% of these annual fluxes. Our study shows the potential significance of tree stem fluxes in intensively-managed plantations and highlights the importance of sustainable nutrition management.

A strategy for optimising catchment management actions to improve water quality

Richard McDowell[1], Marc Schallenberg[2], Scott Larned[3]
[1]Our Land And Water National Science Challenge, Lincoln, New Zealand, [2]University of Otago, Dunedin, New Zealand, [3]NIWA, Christchurch, New Zealand

A myriad of management actions can be applied to reduce anthropogenic pressures on aquatic environments. Appropriate management actions, whether they be mitigations of contaminant transfer to receiving environments or interventions within the receiving environments to alter resilience to a contaminant, are those which are cost-effective and which operate over desired time frames. The stressor-response relationship describes the change in ecological, social or economic value of a receiving environment when impacted by a specific contaminant. Defining a receiving environment × value × contaminant system and determining a specific stressor-response relationship for that system provides valuable decision support strategy to optimise management actions towards a water quality objective. Here we outline a simple method for using stressor-response relationships to help identify the most appropriate management actions for aquatic ecosystems. We use the example of a eutrophic lake to show how the method can be applied to any receiving environment × value × contaminant system.

Vertical distribution of soil carbon following full inversion tillage: implications for C sequestration

Sam McNally[1], Mike Beare[1], Richard Gillespie[1], Craig Tregurtha[1], Erin Lawrence-Smith[1], Mike Hedley[2], Roberto Calvelo-Pereira

[1]New Zealand Institute for Plant & Food Research, Lincoln, New Zealand, [2]Massey University, Palmerston North, New Zealand

Developing technologies or strategies to increase soil carbon (C) and thereby offset the increase in global GHG emissions is of increasing importance. The one-off (or infrequent) use of full inversion tillage (FIT) for pasture renewal has been identified as a promising option to increase soil C. The process of FIT relies on burying C rich topsoil at depth while C depleted subsoil is brought to the surface, thus 'inverting' the soil C profile. This field study investigated the vertical distribution of soil C following FIT during a pasture renewal event in Lincoln, New Zealand. The FIT was performed, during March 2018, to a depth of 30 cm and resulted in a redistribution of soil C compared to the baseline soil C concentrations. On average, the soil C stock in the top 7.5 cm of the soil decreased by approximately 30% while the C stock in the 25-35 cm depth increased by 180% following inversion. Assuming that the new top soil (inverted subsoil) can return to a similar C content of the original top soil, this redistribution of C will provide an opportunity for additional C storage.

Effect of temperature variations on Controlled Release Fertiliser applications and modelling

Tom Meaclem[1], Daniel Holland[1]

[1]Department of Chemical and Process Engineering, University of Canterbury, Christchurch,

Controlled release fertilisers (CRF) use thin biodegradable polymeric membranes to control the nutrient release and improve fertiliser nutrient use efficiency, however the performance of CRFs in-the-field does not achieve the expected efficiency gains. Typically CRFs are designed to release nutrients over 70-90 days. The nutrient release is controlled by Fickian diffusion and hence is influenced by temperature changes through the diffusion coefficient. Over the course of a 90 day growing season, temperature in New Zealand fields will change by 10°C. Current models do not account for how the change in temperature during the release period will influence the diffusion coefficient and hence release rate of nutrients. The purpose of this study was to investigate the effect of these temperature changes on the release rate of nutrient from commercial CRFs.

Two commercial CRFs were studied here, N-control and Polyon, both designed to realise over about 70 days at 30°C. Field data shows that average daily temperatures range from 4°C to 19°C over the September to December period, with significant additional variation in the hourly and daily temperatures. Water release trials of the CRFs show that the release rate at 20°C is 10 times greater than that at 4°C. These experiments were used to estimate the temperature dependence of the diffusivity through the polymer membrane. We then developed a numerical model of the release process to model how changes in the temperature effect the rate of nutrient release. This model reveals that seasonal variations in temperature can alter the timing of the release by up to 30%, when compared with simply using the average temperature over the period. The variation in temperature and hence diffusivity over the release period has not previously been incorporated into release models of CRF, perhaps contributing to the poor performance of CRFs in the field.

Quantifying forest soil microsite variation in Pinus radiata (D. Don) forests and its impact on forest productivity with electromagnetic induction

Priscilla Lad[1], Dr Dean Meason[1], Dr Amanda Matson[1], Dr Marta Gallart[2]

[1]Scion, Whakarewarewa, Rotorua, New Zealand, [2]School of Biological Sciences, University of Canterbury, Ilam, Christchurch, New Zealand

Soil heterogeneity in forest soils can be very large, and this heterogeneity influences a range of physicochemical and microbial processes. In addition, forest soil maps are coarsely surveyed. These factors make it difficult to quantify what site factors have the greatest impact on forest productivity in commercial forests. Further, research can be impacted with large soil heterogeneity within a seemly homogenous experimental blocks. While forest soil heterogeneity is recognised as an important factor in commercial forestry, quantifying this with intensive soil surveying is rarely performed due to the prohibitive cost. Ground electromagnetic induction instruments are increasing being used in agriculture to quantify spatial and temporal variation in soil physical properties, soil water, and chemistry by measuring the soil's apparent electrical conductivity. This is a promising method for commercial forestry to rapidly quantify physiochemical properties over a large area. However, this instrument has rarely been used in more heterogenetic and arguably more complex forest soils. This study examines the effectiveness of the DUALEM electromagnetic instrument (Dualem Incorporated, Canada) in quantifying soil heterogeneity in four of 8 -12 ha Pinus radiata research trials throughout New Zealand. Results to be presented at the conference include if the instrument was able to accurately detect and quantify microsite effects, how measurements correlate with soil moisture fluxes, how it performs on different soils, and if the instrument is a useful tool for the researcher and the forest manager

Irrigation of temperate pastures does not increase the net soil C inputs via photosynthesis

Carmen Rosa Medina Carmona[1,2], Sam R McNally[2], Timothy Clough[1], Mike H Beare[2], John E Hunt[3], Craig S Tregurtha[2]

[1]Department of Soil and Physical Sciences, Faculty of Agriculture and Life Sciences. Lincoln University, Lincoln, New Zealand, [2]The New Zealand Institute for Plant & Food Research, Lincoln, New Zealand, [3]Landcare Research, Lincoln, New Zealand

The use of irrigation to improve dry matter production (DMP) has been steadily increasing. However, it is not clear whether irrigated pastures act as a source or sink of atmospheric CO2. Our objective was to measure the effects of irrigation on the dynamics of newly fixed-C in a plant-soil system under a perennial ryegrass (Lolium perenne L.) and white clover (Trifolium repens L.) pasture.

The experiment consisted of two soil moisture treatments (Dryland and Irrigated) applied to soil mesocosms established with perennial ryegrass-white clover pasture, which were continuously pulse labelled with 13CO2 between December 2016 and March 2017 (e.g. an irrigation season). Following the labelling phase, the soil moisture regimes, for both treatments, were brought to autumn/winter conditions. The mesocosms were destructively harvested at 0, 11, 124, 236 and 348 days after the last labelling event. The partitioning of newly fixed carbon was determined through 13C analysis of herbage, roots, bulk and rhizosphere soil. The soil C input derived from the newly fixed-C was calculated using a two-pool mixing model.

There was greater DMP under irrigated (81 kg ha-1 d-1) compared to dryland conditions (55 kg ha-1 d-1), particularly during the irrigation season. Although, root mass was greater under dryland (12000 kg ha-1) compared to irrigated conditions (9800 kg ha-1), the amount of new C in the soil was similar between the two pastures (ca 2500 kg new C ha-1 for both). However, the amount of new C in the rhizosphere was greater under dryland (530 kg new C ha-1) compared to irrigated pasture (380 kg new C ha-1).

While irrigation increased DMP, there was no difference in the total input of new C to the soil compared to dryland conditions, suggesting that a net loss of C under irrigation might be driven through mechanisms other than reduced C inputs.

Accurate scheduling of irrigation using plant-based measurements.

Alexandre Michel[1], Hamish Brown[1], Pete Jamieson[1,2], Carolyn Hedley[3], Shane Maley[1], Mike George[1], Richard Gillespie[1]

[1]The New Zealand Institute For Plant & Food Research Limited, Lincoln, New Zealand, [2]522 Two Chain Rd, Christchurch 7677, New Zealand, [3]Manaaki Whenua, Landcare Research, Lincoln, New Zealand

Water balance based irrigation scheduling is normally based on soil water measurements. However, sensors usually sample a small volume of the soil, are slow to install, take time to settle in, and require soil type specific calibration. By contrast plants install their own roots in the soil, take a much greater sample of the soils volume and respond to soil water availability in the same way regardless of soil type. We have developed a method that uses measurements of canopy surface temperature (TS) and normalised difference vegetation index (NDVI) in combination with local air temperature (Ta) and solar radiation to estimate evapotranspiration (ET) from a zone. The Ts and NDVI sensors can be quickly installed or be mobile. They integrate the status of all the plants (and the underlying soil their roots explore) in their field of view enabling sampling of large areas or many zones. An experiment conducted in a ryegrass seed crop with three available water capacity zones (Low, Medium and High) showed the plant based method of measuring ET was very accurate and highlighted lower water use by plants grown in the Low zone even though they were fully irrigated. Variable rate irrigation treatments, replacing the ET measured with this method on each zone gave 30 – 70 mm water savings with no yield reduction compared to uniform irrigation application based on neutron probe measurements. With current technology ET monitoring sensors could be set up in different zones to measure water use and easily removed and replaced when cultivation occurs. In the future drones could collect maps of TS and NDVI creating water use maps to inform variable rate irrigation. This would capture the effects of soil and other variability such as crop establishment or disease.

Out with chemical recalcitrance: field evidence that soil organic matter persistence is an ecosystem property

Gabriel Moinet[1], Matthias Moinet[1,2], John Hunt[1], Cornelia Rumpel[2,3], Abad Chabbi[3,4], Peter Millard[1]

[1]Manaaki Whenua Landcare Research, Lincoln, New Zealand, [2]National Centre for Scientific Research, CNRS, Thiverval-Grignon, France, [3]National Institute for Agronomic Research, INRA, Thiverval-Grignon, France, [4]French National Institute for Agronomy Research, Lusignan, France

Describing the temperature sensitivity of soil organic matter (SOM) decomposition is critical for forecasting whether soils in a warming world will lose or gain carbon, and therefore accelerate or mitigate climate warming. The relative temperature sensitivity of SOM decomposition is usually described, using Arrhenius kinetics, as directly proportional to the turnover time of the substrate in laboratory conditions, where substrate availability is non-limiting. However, these conditions are rare in the real soil environment, where substrate availability is limited and where substrates' physicochemical protection may control their turnover time. Here, we assessed the temperature sensitivity of SOM decomposition in situ by measuring soil CO2 efflux at a range of temperatures from root exclusion plots of increasing age and, therefore, with SOM of increasing turnover time. The relative temperature sensitivity of SOM decomposition decreased significantly with increasing SOM turnover time, to become lowest (Q10 < 1.2) in long-term root exclusion plots. Measurements of 13CO2 suggested that the positive temperature response of soil CO2 efflux in short-term root exclusion plots was largely due to the decomposition of readily available (unprotected) root litter. We argue that the physicochemical protection of SOM in the undisturbed soil matrix contributes significantly to defining SOM turnover and that, consequently, the sensitivity of SOM decomposition to short-term changes in temperature may be small or null in the field. Our results provide empirical evidence to suggest that redefining pools of SOM with different turnover times according to their availability rather than chemical structure is warranted to improve model predictions of soil carbon-climate feedbacks.

Mitigating the impacts of pastoral livestock farming on water quality: what have we achieved?

Ross Monaghan[1], Andrew Manderson[2], Les Basher[3], Richard Muirhead[1], Hans Eikaas[4], Chris Smith[5], Rich McDowell[6]

[1]AgResearch, Mosgiel, NZ, [2]Landcare Research, Palmerston North, NZ, [3]Landcare Research, Nelson, NZ, [4]DairyNZ, Mosgiel, NZ, [5]AgResearch, Woodlands, NZ, [6]AgResearch and Our Land & Water Directorate, Lincoln, NZ

A range of measures for mitigating farming's impacts on water quality are now expected as good practice in modern farming systems. However, their level of implementation has varied depending on affordability and the perceived severity of the impact of a particular measure. A broad area of uncertainty that is commonly expressed is how effective a specific measure has been in reducing losses of multiple water quality contaminants. We therefore assessed the effectiveness of some key farm and land management interventions on reducing discharges of multiple water contaminants, specifically nitrogen, phosphorus and sediment. Our objective was to determine how much progress has been made in decreasing contaminant discharges in 1995 compared to 2015 and to determine what loads would look like if no effort had been made. To do this we isolated the specific effects of some key management interventions that have been widely promoted amongst farmers and rural professionals in 1995 and 2015. Spatial estimates of the extent of farming activities for these dates were factored into calculations to ensure that assessments considered the likely important effects of the encroachment of intensive land use practices onto land that has traditionally been deemed less suitable for such intensive activity. This approach used farm typologies, defined for model dairy and sheep-beef farms. The typologies considered both landscape vulnerability attributes (such as soil, topography and climate factors) and land use pressures (such as farm inputs and feed and stock management practices) known to influence the inherent risk of contaminant transport to water.

Urine patches: unique ecosystems that reshape soil microbiomes and N cycling rules

Sergio Morales[1], Md Sainur Samad[1], Charlotte Johns[2], Karl Richards[3], Gary Lanigan[3], Lars Bakken[4], Cecile de Klein[5], Timothy Clough[2]

[1]University Of Otago, Dunedin, New Zealand, [2]Department of Soil and Physical Sciences, Lincoln University, Lincoln, New Zealand, [3]Teagasc, Environmental Research Centre, Johnstown Castle, Ireland, [4]Department of Environmental Sciences, Norwegian University of Life Sciences, Ås, Norway, [5]AgResearch, Mosgiel, New Zealand

Soil microbiomes are intrinsically linked to nutrient cycling, with loss of N as greenhouse gases directly controlled by specific functional groups. However in New Zealand nitrous oxide (N2O) emissions are driven by ruminant urine patches that are known to change the physical and chemical status of soils likely disrupting both microbiomes and known regulators of nutrient cycling. In this study we used a combination of tools to understand the impacts of urine patches on N2O emissions. We aimed to identify what transformation pathways dominated under urine patches, who was associated with these patches and how the paradigm for N cycling developed for nitrate/nitrate treated soils applied within these new conditions. Data was generated using tension tables, high-resolution automated gas-chromatography (GC) to monitor gaseous kinetic profiles (O2, CO2, NO, N2O and N2) and small RNA gene amplicon sequencing of both prokaryotic and eukaryotic communities under short term and long-term incubations. Results confirm that urine patches create unique environments that overrule intrinsic regulators of N cycling and reshape microbial communities in soils. This included the abolishment of pH control over emission ratio of N2O, and an enhancement of rapidly growing organisms, most notably ammonia oxidizing bacteria, that benefit from increase N availability. It also identified fungi as being major contributors of N cycling and emissions, as well as contributions by alternative pathways not accounted for.

Impact of irrigation on soil carbon and nitrogen stocks

Paul Mudge[1], Jack Pronger[1], Alesha Roulston, Scott Fraser[1], Andre Eger[2], Veronica Penny[2], Thomas Caspari[2], Danny Thornburrow[1], Jamie Millar[3], Louis Schipper[3]
[1]Manaaki Whenua - Landcare Research, Hamilton, New Zealand, [2]Manaaki Whenua - Landcare Research, Lincoln , New Zealand, [3]University of Waikato, Hamilton, New Zealand

Irrigation in New Zealand has increased rapidly in recent decades, yet there is surprisingly little known about the impact of irrigation on soil carbon (C) and nitrogen (N) stocks. Processes affecting both C and N inputs and outputs are altered by irrigation and therefore it is not easy to predict the net effect on soil C and N stocks and direct measurements are needed. A recent study revealed that on average irrigated pastoral soils from 30 sites across New Zealand had significantly less C and N than adjacent unirrigated pastures, with differences of 7 t C ha–1 and 0.6 t N ha–1 in the uppermost 0.3 m. Causes for these differences in C and N stocks are not well understood, but could have important implications for national carbon budgets and soil quality. Subsequently, we have sampled an additional 70 paired sites to determine whether the impact of irrigation on soil C and N differs by region, soil type and irrigation duration. Initial results from a directly aligned MSc student project focusing on Pumice Soils in the Reporoa Basin are consistent with the previous study, with less C in the irrigated compared to the unirrigated soils. Soil samples from paired sites in Hawkes Bay, Wairarapa, Canterbury and Otago are currently being analysed for total C and N and results from the full set of 100 paired sites (sampled to ≥0.3 m depth) will be presented. For a subset of paired sites we are also investigating what pools of C and N differ, rates of C and N cycling, the sensitivity of respiration to temperature and microbial community composition. Our ultimate aim is to identify where and how irrigation can be used to maintain, or increase soil organic matter and the multiple associated benefits.

X-ray CT and gas transport-derived pore-network characteristics of a silt loam soil

Karin Müller[1], Nicola Dal Ferro[2], Sheela Katuwal[3], Craig Tregurtha[4], Lis Wollesen de Jonge[3], Per Moldrup[5]
[1]Plant & Food Research, Hamilton, New Zealand, [2]University of Padova, Padova, Italy, [3]Aarhus University, Aarhus, Denmark, [4]Plant & Food Research, Lincoln, New Zealand, [5]Aalborg University, Aalborg, Denmark

The gas transport parameters, gas diffusivity and air-filled porosity are crucial for soil aeration, microbial activity and the emission of greenhouse gases and directly depend on soil structure. We investigated the effect of 15-years intensive tillage on the surface structure of an arable silt loam soil. Our hypothesis was that surface soil structural characteristics like pore connectivity and tortuosity will change under intensive arable production affecting gas exchange. Intact soil cores (0-5 cm) were collected from intensively tilled and direct drilled plots. In total, 32 cores were scanned by X-ray computed tomography (CT). The cores were then used to determine soil-gas diffusivity measured in a one-chamber oxygen diffusion chamber and air-connected porosity measured in an air pycnometer, at the same resolution as the X-ray CT scans, namely ≥ 30 µm. The gas measurements allow the calculation of pore-network connectivity and tortuosity parameters that were compared with the CT-derived structural characteristics. Intensive tillage changed the Dexter index from 8 to 12 indicating a less developed structure under intensive tillage. The X-ray CT analysis revealed a macro-porosity of about 21% for all topsoils, and this was not affected by management. However, the pore size distribution was significantly changed by long-term tillage, and warrants a more in-depth analysis of other morphological parameters of the macro-pore network. In addition, significant positive correlations between the CT-derived structural parameters and the functional gas transport parameters were found, which suggest that X-ray CT could be useful for estimating gas transport parameters.

Measuring losses of N and P from cropping systems using a network of drainage fluxmeters

Matthew Norris[1]
[1]*Plant & Food Research, Hamilton, New Zealand*

Measuring losses of N and P from cropping systems using a network of passive wick drainage fluxmeters

Between August 2014 and May 2015 a network of passive-wick drainage fluxmeters (DFMs) was established on commercial cropping farms to measure nitrogen (N) and phosphorus (P) losses in drainage water from below the root zone. The experimental design includes twelve sites located across five regions (Canterbury, Manawatu, Hawke's Bay, Waikato and Auckland) and twelve DFMs per site. Individual sites were chosen to provide a range of cropping rotations, soil types, climatic conditions and management practices relevant to each region. Measured drainage volumes are validated against modelled outputs generated using a mechanistic soil water balance model. In an evaluation of the three year data set, eleven of the twelve sites were found to be operating in a manner suitable for the generation of robust data on N and P losses in drainage water. Across these 11 sites, average annual N losses ranged from 16-192 kg N/ha with most N (96 %) lost in the nitrate-N form. These losses have occurred predominatly between mid-autumn and early spring (April to September) in conjunction with typically elevated drainage volumes over this period. Average annual P losses ranged from 0.04-0.93 kg P/ha. These represented fairly small net losses, of which the majority (50–95%) was in the dissolved reactive form (DRP) in the drainage water.

Does reduced soil carbon accessibility to microbial decomposition decrease nitrogen losses?

Jonathan Nuñez[1], Gabriel Moinet[1], John Hunt[1], Matthew Turnbull[2], Gwen Grelet[1], Tim Clough[3], David Whitehead[1]
[1]*Manaaki whenua - Landcare Research, Lincoln, New Zealand,* [2]*University of Canterbury, Christchurch, New Zealand,* [3]*Lincoln University, Lincoln, New Zealand*

Concern about organic carbon (C) and nitrogen (N) losses from agricultural soils is increasing. To provide solutions, linkages between soil organic C decomposition and N transformations must be understood. Using soil mesocosms, we investigated processes that lead to N losses while using an innovative approach to manipulate the microbial accessibility of soil C. We manipulated soil C accessibility to decomposition by adding modified allophane, a mineral with high capacity to bind C. Different mass proportions of allophane from zero (control) to 100% were added to soils. Then, we used four independent methods to estimate C accessibility after 1, 2, 3 and 15 days: i) the rate of respired CO2, ii) the 13C isotopic signature of respired CO2 (δ13C), iii) the release of hot water extractable C and iv) C availability index. Our findings to date confirm that C accessibility can be manipulated by adding mineral surfaces to the soil in the form of modified allophane. Effects of C accessibility on inorganic-N formation and nitrous oxide emissions were also assessed. The abundance and expression of soil microbial genes involved in nitrification and denitrification were also estimated to determine functional activity related to changes in the soil N pool. We present relationships between C accessibility, N transformations and their functional linkages with key genes related to nitrification and denitrification. We provide new insights to reveal a mechanistic understanding of processes linking C and N cycling in soils and speculate on changes in management practices that could be used to increase C inputs and stabilisation in soils that will lead to reduced N losses.

Soilscapes for understanding regional soil distributions

Nathan Odgers[1], Pierre Roudier[2], Dylan Beaudette[3], James Thompson[4]
[1]*Manaaki Whenua - Landcare Research, Lincoln, New Zealand,* [2]*Manaaki Whenua - Landcare Research, Palmerston North, New Zealand,* [3]*United States Department of Agriculture - Natural Resources Conservation Service, Sonora, United States of America,* [4]*Davis College of Agriculture, Natural Resources and Design, West Virginia University, Morgantown, United States of America*

Soils are intrinsic parts of the landscape—the product of environmental factors that influence soil development over time. Soil maps are usually generated for regions of interest, whose extents are often arbitrary (administrative units, map sheet boundaries, or some other artificial subdivision of the landscape). The specific assemblages of soils that occur within any such region of interest have been shown to be predictable from combinations of environmental factors; however, in different regions the specific environmental factors as well as their relative influence on soil variability are known to differ. The natural spatial limits of a set of soil-environment relationships constitute another region within which soil may be mapped. We call these natural regions "soilscapes" and demonstrate how cluster analysis of small catchments with respect to soil-forming factors can be used to find them.

Cluster analysis of small catchments in the North Island, New Zealand resulted in classes of small catchments that have similar patterns of soil-forming factors. Classes were spatially distributed in large tracts rather than in noisy mosaics, which suggests that they can successfully capture regional-scale soil-forming patterns. Classes of small catchments may act as soilscapes and can constitute objective spatial domains for developing soil-environment models in.

The role of tephra cover in slope stabilisation following the Last Glacial in Waipaoa Catchment.

Alan Palmer[1], Mike Marden[2]
[1]*Massey University, Palmerston North, New Zealand,*
[2]*Landcare Research, Gisborne, New Zealand*

Tephra accumulating as up-building soil profiles can be used to document the stabilisation of hill and steep slopes in Waipaoa Catchment, Gisborne, at the end of the Last Glaciation. During the Last Glacial, 30-18ka, all steep slopes and most hill slopes were eroding. The Rerewhakaaitu Tephra (ca 17.5ka) was the first to accumulate on favourable sheltered hill slopes, particularly at lower elevations and on Miocene mudstone lithologies. By the time of the Waiohau Tephra (ca 14ka) most hill slopes and some steep-land slopes less than 30* slope, on all lithologies were stable, except for large extant gully systems. Pollens from Kaipo Bog (Urewera National Park), limited local pollen information, and woody debris in favourable positions on slopes and ox-bow sediment traps in local streams, indicate that the stabilisation of the landscape was achieved by rapidly succeeding and spreading native forest. The tephra cover assisted tree establishment by producing soils that were more porous and well drained, yet stored available water for tree survival through summer drought.
The stabilisation of the hill and steep-land landscape was immediately followed by abandonment of the Waipaoa 1 (Last Glacial) river aggradation surface and downcutting by streams throughout the Waipaoa catchment, beginning on the main stem, but proceeding rapidly up the tributaries. Flights of degradation terraces were left behind, each with dateable tephra cover.
The slopes protected by the remnants of the main aggradation terrace and degradation terraces retained a tephra cover very close in age to the terrace protecting them. Slopes unprotected by any terrace leading down to a stream generally have no tephra cover at all or a limited record back to the Waimihia Tephra. Native forest removal has led to catastrophic erosion of tephra cover.

Physiographic Environments of New Zealand: An integrated landscape classification for understanding variation in water quality

Dr Lisa Pearson[1], Dr Clint Rissmann[1,2], Dr Monique Beyer[1], Jessie Lindsay[1], Matt Couldrey[1], Abigail Lovett[1]
[1]Land and Water Science, Invercargill, New Zealand,
[2]Waterways Centre for Freshwater Management, University of Canterbury/Lincoln University, Christchurch, New Zealand

Water quality outcomes vary spatially across the landscape, even when there are similar land use pressures. These differences are often the result of natural spatial variation in the landscape, which alters the composition of the water through coupled physical, chemical and biological processes. Elucidating the impact processes have on water composition is a powerful tool for informing and optimising efforts to improve water quality by matching actions to the known process-level controls.

Physiographic Environments of New Zealand is a project within Our Land and Water National Science Challenge and is supported by a number of regional authorities. The physiographic approach is an integrated or 'systems view', predicated upon the spatial coupling between landscape attributes and the key processes governing water quality outcomes in surface and shallow groundwater. Unlike other mapping and classification approaches, the physiographic approach incorporates water quality, hydrochemical and/or hydrological response signals into a spatial format to identify, combine and classify those landscape gradients that drive variation in water quality outcomes. For example, the relationship between soil drainage class (attribute) and redox (process) can be used to predict soil denitrification potential; or soil attributes, such as texture and permeability, combined with topography can inform hydrological processes, such as the potential for overland flow, lateral flow, and deep drainage which are all pathways water (and contaminants) take to surface water bodies and aquifers. Areas characterised by similar process-attribute classes for both hydrology and redox are defined as Physiographic Units (PGU). Each PGU responds in a similar fashion at the process level to broadly equivalent land use pressures. Comparison of direct water quality measures reveal gradients according to the proportion of PGU with the capture zone, which can be used to estimate the steady-state water composition of surface water and shallow unconfined groundwater with a high degree of confidence.

Changes in soil under irrigation: a summary of research findings

Dr Stephen McNeill[1], Dr Paul Mudge[3], **Veronica Penny**[1], Dr John Drewry[2], Dr Sam Carrick[1]
[1]Manaaki Whenua - Landcare Research, Lincoln, New Zealand,
[2]Manaaki Whenua - Landcare Research, Palmerston North, New Zealand, [3]Manaaki Whenua - Landcare Research, Hamilton, New Zealand

New Zealand has a long history of irrigation, with some areas being irrigated for more than 100 years. In recent times irrigation expansion has occurred at a rapid pace, with the irrigated area roughly doubling every 12 years since the late 1970's. As a result, irrigated land is now a significant component of New Zealand's farming economy and rural landscapes. The introduction of irrigation has resulted in increased productivity, but also intensification in land management through increased fertiliser use and stocking rates.

Farmers have shown a strong interest in how soils change under irrigation, both in terms of maintaining or enhancing the productive capacity of their soils, and demonstrating their sustainable stewardship of New Zealand's soil resource for future generations. Some farmers have reported improvements to their soils after commencing irrigation but, increasingly, anecdotal evidence is not enough, with environmental regulation and consumer markets demanding scientifically validated evidence of sustainable land management practices.

This effect of irrigation on New Zealand soils has also been an ongoing interest in the science sector, though research has been sporadic, being conducted at different times and locations, focussing on different soil attributes, and under different irrigation systems. Some of the previous research is 'hidden' within off-line scientific reports, or archives of now closed research stations. More recent studies include how soil attributes in the loess soils of North Otago responded to a change from dryland to irrigated sheep or dairy land use, and how soil organic matter changes under irrigated land use.

This talk covers some key understandings of how soils change under irrigation, to give a stocktake of where our knowledge is at around key soil attributes. We will also look at what learnings this research has provided us in terms of good management practices, and where there are gaps in our understanding.

Soil microbial community structure and function is influenced by plant secondary metabolites excreted in urine

Michelle Peterson[1], Craig Anderson[1], Trish Fraser[1], Nigel Joyce[1], Denis Curtin[1]
[1]*The New Zealand Institute for Plant & Food Research Limited, Lincoln, New Zealand*

Using urea as a proxy to model the effect of urinary deposition on nitrogen-cycling dynamics neglects the possible effects of components such as plant secondary metabolites (PSMs). Here we compare soil microbial community response to urea and to natural urines from sheep fed different diets.
Soil nitrification was measured following deposition of urine from sheep fed either perennial ryegrass or plantain. PSMs excreted in the urines were analysed by mass-spectroscopy. Urine or urea solution was added to microcosms at equimolar total N concentrations; control treatments had no addition of N or other compounds. CO_2 respiration was measured, and soil mineral N and DNA extracted, from replicate microcosms every 3 days for 30 days. 16S rRNA amplicons were sequenced and temporal microbial community structure was compared between treatments.
Differential analysis of the mass-spectroscopy data indicated 75 compounds unique to, or present in much higher concentrations, in the plantain urine compared to the ryegrass urine. There was a significant treatment effect on the rate of nitrification, CO_2 respiration and microbial community structure with time. nMDS analysis of the sequencing data showed that urea and soil treatments cluster together (≥60% similarity) but were approximately 50% dissimilar to the urine treatments. Urine treatments shared ≥60% similarity in community structure but had distinct differences in biogeochemistry; nitrification was reduced and respiration increased in the plantain urine compared to the ryegrass urine.
Our results illustrate that the contribution of PSMs significantly impact microbial community and function and must not be discounted when evaluating soil N-cycling dynamics.

Estimation of soil carbon stocks using a newly developed automated sensing platform

Dr. Matteo Poggio[1], Dr. Michael Blaschek[1], Dr. Pierre Roudier[1], Dra Carolyn Hedley[1]
[1]*Manaaki Whenua - Landcare Research, Palmerston North, New Zealand*

Estimation of soil organic carbon (SOC) stocks is fundamental to monitoring the processes of carbon sequestration or loss. Conventional methods for assessing SOC stocks are very time consuming and costly. Therefore we contributed to the design and development of an automated soil core scanning method in collaboration with researchers from CSIRO, Australia, to consistently speed acquisition of soil attribute data. The multi-sensing platform combines a visible near-infrared (VisNIR) spectrophotometer, a γ-ray densitometer and a charged coupled device (CCD) camera. The platform allows high resolution scanning of an intact core at field conditions without pre-processing: the γ-ray densitometer provides estimations of bulk density and the VisNIR spectrophotometer is capable of predicting soil chemical and physical properties such as organic carbon, clay content, cation exchange capacity, pH.
A set of approximately 430 soil cores, from 48 locations around New Zealand, were collected to test the sensor platform. Entire soil cores were extracted to 60 cm depth and analyzed at 2.5 cm increment from 0 to 30 cm depth and 5 cm increment from 30 to 60 cm depth. Spectral and γ-ray attenuation data were simultaneously recorded for each scan depth. The cores were then cut into 10 cm increments for conventional laboratory analysis. A total of 110 cores were analyzed for bulk density and carbon (by Leco Analyser) to develop calibration models for SOC stocks through chemometric and statistical algorithms.
Expected results are important for improving New Zealand's understanding and verification of total carbon emissions/sequestration. Furthermore, the operational easiness and efficacy of these soil sensing methods will encourage the adoption of these rapid and cost effective techniques as an enhancement of standard laboratory analysis enabling researches with high density sampling for a better comprehension of spatial and temporal soil variability.

Optimising soil conditions for methane oxidation - using land use change as an example

Dr Sally Price[1]
[1]*Lincoln University*

Methane is ever increasing in the atmosphere and this upward trend has been the most noticeable since the industrial revolution (722ppb pre 1800 to 1840ppb in 2016). New Zealand has a greenhouse gas budget largely dominated by agriculture and as a result one of the major gases produced by this sector is methane. Soil methane oxidation is a natural process which is counterbalancing to biospheric methane production. Landuse change is widespread in New Zealand and can come in many guises - it can take the form of broad scale conversion of indigenous forest to agriculture, within sector changes eg arable to dairy, and the reverse, regeneration of marginal hillslopes. These changes influence the functioning of the soil underneath these ecosystems in terms of soil methane oxidation. There are 7 key factors which regulate methane oxidation in a model pristine indigenous forest soil environment, one of which is disturbance. An example of disturbance in this forest soil is that the removal of the litter layer increased methane oxidation by approximately 20% under field conditions in the short term. To understand what is happening under landuse change scenarios with regard to methane oxidation, the 7 key factors are investigated. Methane oxidation under landuse change processes provides the ideal scenario to demonstrate which key variables need to be monitored to work towards better functioning, healthier soil environments.

A simple tool for estimating water use efficiency in irrigated and non-irrigated fodder crops

Jack Pronger[1], Paul Mudge[1], Scott Graham[2], John Hunt[2], Johannes Laubach[2], David Whitehead[2]
[1]*Manaaki Whenua - Landcare Research, Hamilton, New Zealand,* [2]*Manaaki Whenua - Landcare Research, Lincoln, New Zealand*

The expansion of irrigation for agriculture in New Zealand is increasing demand for water and therefore it is important to explore approaches to increase water use efficiency (WUE). One approach would be to optimise crop-species selection together with irrigation rates, but high spatial variation in soil, climate, and plant water requirements makes this selection and optimisation at any one site difficult. Therefore, a simple and cost-effective tool to measure WUE in situ is needed. We investigate here whether such a tool may be based on the measurement of natural carbon isotope discrimination (Δ13C) in plant leaves. Δ13C should provide information on how C3 plants control the trade-off between water use through transpiration and carbon gain via photosynthesis (i.e. WUE) and is suitable for scaling from leaves to canopies and paddocks. At Ashley Dene Research Station in Canterbury we compared WUE calculated from Δ13C of plant leaves (WUEΔ13C) to WUE calculated from continuous measurements of evaporation and net ecosystem exchange (NEE) of CO2 using eddy-covariance (EC) over irrigated and non-irrigated lucerne. Models were used to partition gross primary production (GPP) from NEE and transpiration (ETI) from total evaporation. WUETI was then calculated as GPP divided by ETI. Plant biomass was harvested regularly for one year from replicated random locations within the footprint of the two EC systems and analysed for Δ13C. Similar seasonal trends, and strong positive correlations, were found between WUEΔ13C and WUETI at both sites. Both WUEΔ13C and WUETI were greater (~20%) at the irrigated site, suggesting well managed irrigation could improve both productivity and WUE. Findings are consistent with previous results from non-irrigated pastures in the Waikato. Thus, it appears promising that a calibrated tool based on leaf Δ13C measurements can be developed to select pasture species to optimise site-specific WUE under both irrigated and non-irrigated management.

RPR Revisted 5: The fundamental causes of P loss and its reduction with RPR

Dr Bert Quin[1], Dr Gordon Rajendram[2]
[1]Quin Environmentals (NZ) Ltd, St Heliers, Auckland, New Zealand, [2]Eurofins NZ Laboratory Services Ltd , Penrose, Auckland, New Zealand

The extent to which reactive phosphate rock (RPR) is recognised in Overseer® as causing less phosphorus (P) loss from soils than soluble P is currently limited to consideration of differences in measured soluble P (dissolved reactive P or DRP) in runoff.
The difference between RPR and soluble P becomes much greater, especially on soils with <40% P retention (ASC), when leaching of fertiliser P beyond the root zone is included. Published research since the 1980s shown that 10-30% of applied soluble P is lost from low P-retention soils.
As far as losses of particulate P are concerned, the 30-70% of P runoff that comes from particulate P (P adsorbed onto soil particles) is often considered to be independent of the type of P being used. However, field data clearly demonstrates that RPR maintains maximum pasture growth with considerably lower readily-available (ie water-soluble and weakly-adsorbed) P levels (as measured by the Olsen P test for example) than does soluble P. This has important consequences.
The first is that the dissolution of RPR particles is dependent largely by particle size, soil pH, soil moisture and soil calcium status. On average, a molecule of carbonoapatite (RPR) takes 1-3 years to be dissolved into the soil solution and become part of the soil adsorption/desorption equilibrium processes. Typical maximums of weakly-adsorbed P (Olsen P) that are achieved with long-term RPR are less than 30 ug/gm soil, a good match with the concentrations of weakly-adsorbed P that pasture, especially clover, requires for optimum growth. These levels are maintained by ongoing dissolution of RPR particles.
Soluble P fertilisers on the other hand maintain soil concentrations of very weakly adsorbed P up to hundreds of times higher than this for many weeks in the dissolution zone surrounding soluble-P fertiliser particles. These concentrations occur predominantly near the surface, where the fertiliser is placed. It is the most weakly-adsorbed P in carried-off particulate P that is most likely to be desorbed in typically mildly-acidic runoff water, streams, rivers and lakes as the P equilibrium changes with dilution, and becoming available for weed and algal growth.
Particles of undissolved RPR in the soil are far less likely to reach receiving water than other soil particles or undissolved particles of soluble P fertiliser, because of the much higher density of RPR (specific density of individual particles 2.5, compared to typical values of 0.8 for near-surface soil particles and 1.2 for fertiliser particles carried off in water).
Finally, the greatly elevated levels of weakly adsorbed P in the vicinity of dissolving soluble P granules is known to produce considerably higher concentrations of plant P in the weeks after fertilizer application due to excessive uptake. This excretion of this excessive P in dung exacerbates the uneven redistribution of this nutrient in pastoral farming, especially hill country. More intensive research on farms with a long-term history of RPR should be a priority.

Maintaining and improving the value of Māori land: Case study from Wairoa District

Dr Megan Balks[2], Dr Garth Harmsworth[1],
Johnathon T. Rau[1,2]
[1]Landcare Research, [2]University of Waikato

Traditional Māori beliefs influence the way Māori view and manage land. When Ranginui separated from Papa-tū-ā-nuku multiple responsibilities were given to Māori to help sustain the well-being of people, their communities and the natural resources at hand.
The Wairoa District, on the East Coast of the North Island of New Zealand as at 2013 had Māori owned land totalling 47,020 Ha (11.4% of the District) of which 4,663 Ha is in Land Use Capability classes 1-3. Much of the Māori owned land is underdeveloped with less than 1 Ha in horticultural land use.
As at 2013 58.6% of the Wairoa District population identified themselves as Māori. Since 1991 the District's population has steadily fallen which can be attributed toward the lack of job and career opportunities. The objective of my study was to provide information to help inform landowners (including Māori) who may wish to invest in horticulture which could improve the economic situation of the District.
Field work involving local scale climate mapping and soil characterisation of areas with potential for horticulture in Wairoa District was completed in 2017. Constructed climate and topographical maps with existing soil maps were evaluated against known crop growth requirements to produce crop potential maps identifying areas with potential for crop production. Horticultural crops included in this study include kiwifruit, apples, cherries.
Between mid-April – 31 October 2017, 45 portable iButton temperature loggers were deployed throughout Land Use Capability classes 1-3 in the Wairoa District and were set to record hourly temperature. When regressed against nearby climate stations, long term (18 -26 years) temperature datasets were derived from the short term iButton datasets. From the long-term datasets local scale chill hour, growing degree days and October frost risk maps were constructed for the Wairoa District.
The crop potential maps can enhance a land owner's ability to make informed decisions resulting in economic benefits to whanau, community and the Wairoa District.

Nutrient Management for Vegetable Crops in NZ – a major update for the industry

Jeff Reid[1], Jeff Morton[2], Adrian Hunt[1], Bruce Searle[1], Paul Johnstone[1], Stephen Trolove[1]
[1]Plant & Food Research, Hastings, New Zealand, [2]MortonAg, Napier, New Zealand

Since 1986 a single book, Fertiliser Recommendations for Horticultural Crops, has been utilised as a source of nutrient management guidelines by NZ vegetable growers. However, much of the business, regulatory, social and scientific context of horticulture has changed over the last 32 years. Recognising these changes, we have produced a new book Nutrient Management for Vegetable Crops in NZ, to be a resource of scientifically-defensible best practices. Here we outline the major differences from the 1986 recommendations.

An important change is that the new recommendations align with the FANZ 2013 Code of Practice for Nutrient Management. The 1986 approach of fertilising to achieve target soil test values was re-appraised, and too often the evidence for the recommended values – and the concept itself – was inadequate. Instead, the new recommendations emphasise results from field-tested models of crop response to nutrient supply (PARJIB, the Potato Calculator, critical nutrient dilution curves). Another change is use of soil N tests (mineral N, anaerobically mineralisable N). These may be replaced as new science comes on stream.

The new recommendations recognise that vegetable crops differ greatly from pastures and most arable crops, and this affects the way nutrients must be managed for them. To achieve crop quality requirements, usually plant populations are small and crop durations are short, but growth rates per plant must be very large. So their relatively sparse root systems must achieve high rates of nutrient uptake. In the past this has contributed to a perceived need for very high rates of fertiliser application. Combined with a tendency for much of the fertiliser to be applied close to sowing this can increase the risk of nutrient losses to the wider environment. The new recommendations emphasise where careful placement and timing of fertilisers can lead to better financial and environmental outcomes.

Land use transformation; can science de-risk barriers to land use change?

Dr Robyn Dynes[1], **Alan Renwick**[2], Paul Johnstone[3], Warren King[4], Lania Holt[5]
[1]AgResearch , Lincoln, New Zealand, [2]Lincoln University, Lincoln, New Zealand, [3]Plant & Food Research, Havelock North, New Zealand, [4]Scion, Rotorua, New Zealand, [5]AgResearch , Hamilton, New Zealand

There is increasing recognition that the land-based sectors will need new primary production systems to break the lock-step relationship between profitability and production on one hand and environmental footprint on the other. Business as usual will not be sufficient to deliver more value with a lower footprint across NZ and create step rather than incremental change. These changes are needed to meet environmental limits, maintain social license to farm, and to derive greater value from exports in a changing future.

Assessment of candidate next-generation farm systems and analysis of their comparative ability to deliver value – financial, environmental and social/cultural – is, however, critically lacking. A framework using multi-criteria decision making (MCDM) was developed because it provides the ability to simultaneously consider multiple domains where selection of best alternatives is highly complex. The approach described here recognises that for land owners and managers, while this assessment is primarily a business decision, it is also influenced by other factors. The aim is to use the framework with land owners and managers to explore opportunities for next generation systems and to identify gaps in knowledge that require research investment. The MCDM was developed based on published literature and refined following feedback from industry, consultants and rural entrepreneurs.

The framework has been used with rural entrepreneurs to explore the criteria which any new enterprise must deliver to the existing business and to identify gaps in knowledge which are barriers to land use transformation. A case study from an east coast business considering a transformational change in land use will be presented. The example highlights how the various dimensions of the decision problem are weighted, within the land and soil resources available and used to identify major barriers to change. The opportunity for science to 'derisk' decision making will be discussed.

Can we defensibly estimate catchment-scale flowpaths contributions based on widely available geospatial data?

Aldrin Rivas[1], Dr. Roland Stenger[1]
[1]*Lincoln Agritech Ltd., Hamilton, New Zealand*

At the catchment-scale, a combination of pathways is responsible for the transfer of water, and contaminants transported by it, from a parcel of land to a receiving surface water body. These pathways have differing associated lag times and attenuation potentials, which makes it critical to understand them when trying to accurately link observed surface water effects to land use or land management. This study developed a deductive approach for estimating the contributions of different pathways to catchment-scale water flows utilising databases widely available in New Zealand (Fundamental Soil Layers, QMap). Soil and geological properties in these databases were combined and the dominant flow pathway was identified for each polygon with a unique set of combination of properties affecting flow partitioning. First, flow was partitioned into two main components: fast (comprising overland flow and interflow) and non-fast (shallow and deep groundwater flow), using a matrix of properties representing a) physical impediment for vertical flow of water and b) soil drainage status. This was further refined by considering water storage capacity and slope. These main components were further divided using sequential flow partitioning steps as water percolates through the soil profile. The entire flow partitioning process was implemented in GIS and applied to five catchments in the Waikato region with varying hydrological response properties (baseflow vs. quickflow dominated). Resulting maps generated for the study catchments visualised the spatial distribution of dominant flow pathways. An aggregation of the spatial coverage of the different dominant pathways yielded the flow contribution proportions at the catchment scale. Initial results suggest that the existing soil zone data allow fast and non-fast flow contributions to be realistically estimated. However, the scarcity of data from below the soil zone poses a substantial challenge for the desired partitioning between shallow and deeper groundwater pathways.

Is Disruption the New Black? A Luddite's View.

Dr Ants Roberts[1]
[1]*Ravensdown*

What would Norman Taylor, a soil science pioneer and visionary in earlier days, think of the current challenges we have in agriculture? There are many e.g., water quality and quantity, climate change, soil erosion and contamination, none of which are simple issues to deal with anymore, but tackle them we must or Gaia is in trouble! Disruption is a word frequently over used in the media and by thought leaders today, and not only in agriculture. It is often used in a negative or threatening sense but disruption has happened often in world agriculture through the ages and it still survives and feeds most of the burgeoning world population. There are a myriad of new technologies with potential to revolutionise aspects of our current system of agriculture but are they all as good as they are made out to be in terms of practicality, human nutrition and environmental consequence? Are there any new frontiers in terms of soil research and practice which may help agricultural production systems move forward? Let's discuss all these questions and more in this address.

Water retention properties of stony soils

Balin Robertson[1], Peter Almond[1], Sam Carrick[2], Veronica Penny[2], Andre Eger[2], Henry Chau[1], Carol Smith[1]
[1]*Lincoln University, Lincoln, New Zealand,* [2]*Landcare Research, Lincoln, New Zealand*

Environmental models consistently predict stony soils as being vulnerable to nutrient leaching because of their low water storage and high hydraulic conductivity. However, leaching predictions are based on limited experimental research, and rely mostly on estimated soil water attributes. Nutrient leaching models that New Zealand uses for nutrient discharge regulation are sensitive to soil attribute data, particularly water holding capacity and field capacity (FC). In New Zealand, FC is taken as the water content at 10 kPa tension, which is applied to all soils. This paper is aimed at determining the appropriate water tension for FC, and key drivers of its variation, in stony soils. Multiple locations with soils of varying stone content were chosen for field sampling across the Canterbury region. All sites were under pastoral dairy grazing. At each site, two sampling locations were selected, one site on land that has been irrigated for > 3 years, the other on land that has never been irrigated. Field work was conducted in winter to early spring, to ensure the antecedent soil moisture was near FC. At each site, an initial infiltration experiment was conducted to thoroughly wet the soil. After two days drainage (~FC), a 30 x 30 cm soil pit was excavated in 10 cm increments to 60 cm depth. In each increment, water tension was measured with tensiometer probes, and samples collected for measurements of particle size distribution, rock fragment volume and size, carbon content, specific surface area and soil water content. Results from our study will show the variation in FC tension that can occur down a soil profile, among different stony soils, and between dryland and irrigated practices. Preliminary results indicate FC may occur at tensions less than 10 kPa, implying that changes in nutrient discharge predictions for Canterbury stony soils may be necessary.

Resource management challenges in today's era

Sam Robinson[1]
[1]*Hawkes Bay Farmer*

The presentation will comment on NZ society's changing attitude to the use and development of natural resources for economic benefits.

It will argue that there is an important need to involve science and scientists in policy development, management and monitoring.

NZ society needs to regain its understanding of science and respect for scientists, including where they can contribute to Resource Management policy.

Partitioning the temperature dependence of microbial respiration from root inputs and soil organic matter.

Jasmine Robinson[1], Shaun Barker[2], Louis Schipper[1]
[1]*The University of Waikato, Hamilton, New Zealand,*
[2]*University of Tasmania, Hobart, Australia*

Carbon storage in soil is an increasingly important research area as it is widely accepted that increasing soil C and reducing C loss from soils has an overall benefit for both global greenhouse emissions and local productivity. However, the stability of soil C under different management practices is not well understood and is difficult to observe in situ. Using a newly developed method to rapidly analyse soil respired CO2 for δ13C, 13C analysis was used to trace the movement of newly incorporated, labelled carbon (root inputs, enriched via pulse-chase labelled plant growth) through soil and into respired CO2 to examine how land management practices affect soil carbon stability and respiration response to temperature and moisture changes.
A δ13C enriched, stony silt loam soil was enriched with δ13C through root inputs of pulse-chase labelled of pasture, grown over a three month period (under both irrigated and dry-land conditions). The soil, including enriched root inputs (new carbon), was incubated for 20 hours at 20 temperatures (~4 – 50 °C) using a temperature gradient method. The respired CO2 was analysed for total CO2 and δ13C using a modified Los Gatos, Off-axis ICOS carbon dioxide analyser. A two-component mixing model was used to separate the CO2 into source components to determine the contributions of the recently added enriched soil C and old soil C, to total respiration. Preliminary data showed that respiration rates from both sources were temperature dependent and the enriched carbon source was more temperature sensitive than older carbon. A higher temperature sensitivity suggests the recently added carbon decomposes more readily than old soil carbon and is therefore at a greater risk to be lost from soil, with temperature increases.

Does plantain sward affect N2O emissions during different seasons?

Jimena Rodriguez[1], Peter Kemp[1], Soledad Navarrete[1], Mike Hedley[1], James Hanly[1], David Horne[1], Peter Bishop[1]
[1]*Massey University, Palmerston North, New Zealand*

In dairy systems, urine patches are hot spots for nitrous oxide (N2O) emissions due to the high urea nitrogen (N) concentration. Several studies have indicated that the use of novel pastures such as plantain (Plantago lanceolata L.) can reduce N losses from the grazed systems to air and water. Relative to perennial ryegrass (Lolium perenne L.) and white clover (Trifolium repens L.) swards, cows grazing plantain excrete smaller quantities of N in urine thereby lowering N2O emissions from the urine patch. Recently, some studies have also suggested that plantain bioactive compounds, mainly aucubin, could play a role with inhibiting the nitrification process in the N cycle.
The potential for plantain to decrease N2O emissions was evaluated in two field experiments conducted at Massey University's Dairy Farm 4 on a Tokomaru silt loam. Treatments were 'plantain urine' (PLU), 'ryegrass urine' (RGU) and control (NIL) (only water), which were applied to both plantain and ryegrass pastures. These experiments were carried out during two different seasons: spring 2017 and early autumn 2018. Nitrous oxide was measured using the static chamber method. Soil samples were taken to determine soil mineral N and soil moisture content. In spring and autumn, N2O fluxes from ryegrass urine were higher ($P<0.0001$) than from plantain urine due to lower urea concentration in the plantain urine. During spring, N2O fluxes from the ryegrass pasture were higher ($P<0.05$) than from the plantain pasture. However, in the autumn trial the plantain sward produced wetter soils ($P < 0.05$) resulting in the plantain swards producing higher ($P<0.05$) N2O compared to ryegrass pasture. Therefore, N2O emissions were affected by both differences in urine urea content and differences in environmental conditions and, in this experiment, plantain treatments were higher in autumn than spring due to higher soil moisture content.

How can soil science benefit from the data revolution?

Pierre Roudier[1], Paul Johnstone[2], J Sharp[3], R Dynes[4], C Hedley[1]
[1]Manaaki Whenua Landcare Research, Palmerston North, , [2]Plant & Food Research, Hawke's Bay, [3]Plant & Food Research, Lincoln, [4]AgResearch, Lincoln

The last 20 years have witnessed a range of disruptive developments in information technologies. These developments have impacted many fields of science, and soil science is no exception. As a consequence, more data are being generated than ever before – a phenomenon described as the "data deluge" – which has a massive impact on science, and has seen whole disciplines moving from being data-poor to data-rich. Sensing technologies, along with the ability to store and process large volumes of data underpin this revolution.

The "data deluge" challenges soil science because the form that the flow of incoming data takes is often different from the traditional soil datasets. Traditional reference measurements are very demanding, both in time and associated costs, resulting in low numbers of sampling locations. The development of sensing technologies generates another type of soil data where soil properties are observed indirectly in time and/or space at a much higher resolution (e.g. proximal soil sensing methods and wireless sensor networks).

Simultaneously, new analytical capabilities have developed to support the exponential increase of data being created. Parallel developments in computing hardware and methods such as machine learning, are opening ways to tame this "data deluge". Additional progress in layering data spatially and temporally, and coupling these with predictive models, are also offering new opportunities to extract greater value from data, and importantly consider a range of biophysical, economic, social and cultural outcomes simultaneously.

Coupling these sensing and analytical advances with new approaches to manage farm systems at much finer resolution has future promise for land managers to increase productivity, minimise over application of resources (e.g. water, nutrients, agrichemicals), and reduce the risks of contaminant loss to the environment.

This presentation will review the opportunities and risks that are offered by the data revolution and explore what they mean in a New Zealand context.

Efforts towards a national scale, fine resolution grid of soil pH

Dr Pierre Roudier[1,2], Dr Anne-Gaelle Ausseil[1], Dr James McCarthy[1], Dr Nathan Odgers[1], Dr Sarah Richardson[1]
[1]Manaaki Whenua - Landcare Research, , New Zealand, [2]Te Pūnaha Matatini, , New Zealand

Soil pH has always been an attribute of interest for soil scientists --- but this is also the case outside soil science. pH is a major input variable for crop suitability rules, for soil ecosystem services modeling exercises, and it has been widely used as an explanatory variable for species distribution models in ecology.

Despite the importance of this attribute across scientific disciplines, soil pH information (as a map) is not easy to source in New Zealand, particularly at the national scale. The main nation-wide map of soil pH for New Zealand is one of the New Zealand Fundamental Soil (FSL) layers, generated by pedologists more than 30 years ago, and based on their best guess of the most likely pH value for the whole profile, for every Land Resource Inventory (NZLRI) polygon. It is widely regarded by NZ soil scientists as a qualitative, outdated resource.

The digital soil mapping (DSM) framework offers an opportunity to update and improve this map. DSM is building quantitative, statistical relationships between points observations of soil attributes, and a suite of environmental covariates (often derived from remote sensing). As a result, continuous grids of soil attributes can be generated. A nice addition is that uncertainty of the estimates can also be mapped.

This paper reports on the efforts towards the creation of a soil pH grid at the national scale and at a fine spatial resolution (100 m). Several thousands of soil pH observations were collated, along with a suite of climatic, topographic, geologic environmental layers. As a result, several spatial layers were created for different depth intervals (0-5 cm, 5-10 cm, 10-30 cm, 30-60 cm, 60-100 cm), according to the GlobalSoilMap specifications. The accuracy of the resulting maps was assessed against both the reference soil profile measurements and the FSL map.

Relative Gas Diffusivity; an integrative tool for estimating N2O emissions from soils?

Camille Rousset[1], Professor Timothy Clough[1], Professor Peter Grace[2], Doctor David Rowlings[2], Doctor Clemens Scheer[2]
[1]Lincoln University, Lincoln, New Zealand , [2]Queensland University of Technology, Brisbane, Australia

Nitrous oxide (N_2O) is a greenhouse gas and contributes to stratospheric ozone depletion. Agricultural soils dominate anthropogenic N_2O emissions. Unlike most developed countries, agriculture is the largest contributing sector representing 49% of total emissions from the use of fertiliser and from animal excreta, beyond the energy sector in NZ. Better understanding of the mechanisms behind this arable soil phenomenon is a key to reducing greenhouse gases emissions. Currently, there is very limited information on how soil physics affects N_2O emission, especially relative soil gas diffusivity (Dp/Do).
This study was conducted to determine the effect of soil type, bulk density (ρb) and matric potential on Dp/Do and the associated N_2O fluxes in order to further explore the results obtained by Balaine et al. in 2015. We hypothesised Dp/Do would be a good independent factor for estimating N_2O emission potential. The interaction between Dp/Do and N_2O fluxes was investigated using 432 repacked soil cores that were saturated with a nitrate solution and placed on tension tables at 9 levels of matric potential, 3 levels of ρb and using 4 different soils. After equilibration, N_2O fluxes, Dp/Do, inorganic-N concentrations, and soil physical characteristics were determined.
Emissions of N_2O increased at the lower levels of matric potential and were consequently, negatively correlated with the air filled pore space due to having the optimal anaerobic conditions for denitrification process. For soils with high water retention level, emissions of N_2O peaked as soil ρb increased due to increasing microporosity. An increase in organic carbon concentration in soil produced an increase in N_2O emissions. The correlations between Dp/Do and N_2O fluxes, show the same trends observed by Balaine et al. N_2O fluxes were related to the soil's air entry potential, with maximum emissions occurring at a Dp/Do close to 0.006, independent of soil ρb and soil type.

Source-tracking cadmium in New Zealand agricultural soils: a stable isotope approach

Dr Mahdiyeh Salmanzadeh[1,2], Dr Adam Hartland[1], Professor Claudine Stirling[3], Dr Megan Balks[1], Professor Louis Schipper[1], Dr Chaitanya Joshi[4], Dr Ejin George[3]
[1]Environmental Research Institute, School of Science, University of Waikato, Hamilton , New Zealand, [2]Waikato Istitute of Technology (Wintec), Hamilton , New Zealand, [3]Department of Chemistry and Centre for Trace Element Analysis, University of Otago, Dunedin, New Zealand, [4]Department of Mathematics & Statistics, University of Waikato, Hamilton, New Zealand

Cadmium (Cd) is a toxic heavy metal, which is accumulated by plants and animals and therefore enters the human food chain. In New Zealand (NZ), where Cd mainly originates from the application of phosphate fertilisers, stable isotopes can be used to trace the fate of Cd in soils and potentially the wider environment due to the limited number of sources in this setting. Prior to 1997, extraneous Cd added to soils in P fertilisers was essentially limited to a single source, the small pacific island of Nauru. Analysis of Cd isotope ratios (ε114/110Cd) in Nauru rock phosphate, pre-1997 superphosphate fertilisers, and Canterbury (Lismore Stony Silt Loam) topsoils (Winchmore Research Farm) has demonstrated their close similarity with respect to ε114/110Cd.
We report a consistent ε114/110Cd signature in fertiliser-derived Cd throughout the latter twentieth century. This finding is useful because it allows the application of mixing models to determine the proportions of fertiliser-derived Cd in the wider environment. We believe this approach has good potential because we also found the ε114/110Cd in fertilisers to be distinct from unfertilised Canterbury subsoils. In our analysis of the Winchmore topsoil series (1949-2015), the ε114/110Cd remained quite constant following the change from Nauru to other rock phosphate sources in 1997, despite a corresponding shift in fertiliser ε114/110Cd at this time.
We can conclude that to the present day, the Cd in topsoil at Winchmore still mainly originates from historical phosphate fertilisers. One implication of this finding is that the current applications of P fertiliser are not resulting in further Cd accumulation. We aim to continue our research into Cd fate, mobility and transformations in the NZ environment by applying Cd isotopes in soils and aquatic environments across the country.

Progress towards quantifying some environmental implications of New Zealand dairy sheep systems

Diana Selbie[1], Ross Monaghan[1], Amanda Judge[1], Natalie Bartlett[1], Bob Longhurst[1], Brendon Welten[1], Chris Smith[1], Thomas Macdonald[2]
[1]AgResearch, Ruakura Research Centre, New Zealand, [2]Spring Sheep Milk Co., Waikato Innovation Park, New Zealand

Locally and globally there is increasing pressure to protect water quality and comply with environmental legislation. This is particularly evident for more intensive agricultural land uses such as dairy cow farming. Dairy sheep provide an alternative dairy farming system with the potential for lower environmental impact whilst maintaining the same competitive advantage of New Zealand pastoral systems i.e. utilising pasture as a low cost feed source and maintaining the valuable brand image of animals grazing outdoors.

Research in the MBIE dairy sheep programme aims to quantify some of the environmental implications of NZ dairy sheep systems and, in doing so, provide a robust dataset to support the development of farm systems models. We present early research findings from a nitrogen leaching experiment under grazed dairy sheep at Spring Sheep Dairy near Taupo. Other progress as well as future research directions will also be discussed.

Can organic farming reduce nitrate leaching in polluted and sensitive catchments? A critical review

Selva Selvarajah[1]
[1]Enviroknowledge Limited, Dunedin, New Zealand

Keywords: nitrate leaching, regional rules, mitigation, conventional farming

In New Zealand, in the past decade, there have been increasing concerns on declining catchment water quality which was linked to increased nitrate leaching from intensive farming activities. In response, several regional councils have been introducing regional rules to control nitrate leaching from farming activities. A wide ranging nitrate leaching mitigation measures such as riparian management, stock feed manipulation, reducing stocking rate and nitrogenous fertiliser application, deferred farm dairy effluent irrigation, and provision of feed-pads, standoff pads and winter housing for grazing stocks have been promoted to reduce nitrate leaching. Organic farming has been gathering global and local popularity among consumers judging by its rapid growth rate. Last year, the total size of the organic sector in New Zealand was estimated as $600 million of which 60% was from export with an annual growth rate of 15%. Organic farming has been perceived as having lower environmental footprints. If so, why organic farming has not been promoted as a nitrate mitigation tool in New Zealand?

The main aim of this paper was to critically and scientifically assess relevant overseas and New Zealand research comparing nitrate leaching between organic and conventional farming systems.

It was clear that organic farming leached lower nitrate-N compared to conventional in a range of farming systems. Nitrate-N leaching loss in organic systems has been estimated as 8-50 kg N/ha/year which was 50-70% of that of the conventional farming. On a product weight/kg nitrate-N leaching basis, organic farming can outperform conventional farming consistently. Based on the information assessed, realistically, a reduction of 30-50% of the N loading may be possible by large scale organic conversions in intensively farmed catchments. Extensive NZ based organic system nitrate leaching research and consideration to organic farming as a mitigation tool are timely and urgent.

Reflections on the implications of the 'Digital Age' on delivery of solutions for NZ farming

Mark Shepherd[1], David Wheeler[1], James Turner[1], Bruce Small[1]
[1]*Agresearch, Hamilton, New Zealand*

The global challenge: produce more food, more sustainably on a planet with scarce resources and under changing climate. However, the increasing miniaturisation of technologies, the reducing cost of telecommunications and data storage, the increasing computing power, and the development of artificial intelligence and analytics offer new options to meet these challenges. Although 'digitalisation of agriculture' has potential to rapidly move us well beyond business as usual, the big question is: what role do scientists play in realising this potential?
Despite the rapid development of new technology, there still needs to be strong, science-based evidence that the technologies are actually delivering what they promise, so that farmers, consumers and regulators have confidence in the outcomes. Priority research areas therefore include demonstrating the value of adopting new technologies, and providing the scientific evidence that the technology is solving complex problems (validation). There is also a strong social component to adoption, use of, and confidence in these technologies.

Furthermore, while digitalisation of agriculture can aid delivery of new solutions, we argue that huge gains in developing new solutions will be made by the 'digitalisation of science'. Scientists must utilise the new technologies to develop new scientific methods and ways of working. In particular, low cost data collection combined with analytics provides opportunity for powerful new scientific capability, enabling us to better understand, and utilise, biological variability; and can serve as a catalyst for more effective inter-disciplinary research to tackle complex problems.

However, changes to the way we work will be required to achieve these goals including: organisational changes (as technological advances will drive the pace of change in agriculture and thus the pace of the supporting science); agile project management; new skills and capabilities; and collaborations with new partners (e.g. the technology industry). Challenging and exciting times are ahead.

Soil quality from an ecosystem restoration perspective

Robyn Simcock[1], Jo-anne Cavanagh[1]
[1]*Manaaki Whenua Landcare Reseach NZ, Auckland, New Zealand*

Soil quality is most often considered from a managed land perspective, with the indicators, and associated target values, most relevant for agricultural and horticultural species. These are non-native, and generally bred over generations to maximise productivity under high fertility. Further, the land is treated to enhance uniformity and evenness of productivity using fertilisation, drainage, irrigation and physical treatments. However, soil quality viewed from the perspective of restoring native ecosystems is often very different. Native plants may have hundreds of specialist mycorrhizal associations. Many mycorrhizae are negatively impacted by fertilisation (particularly P fertilisers), hence a low Olsen P maybe important, and reduce competitiveness of (non-native) legumes. Similarly, high available nitrogen and low C:N ratios increase competitiveness of non-native grasses. Native trees may live many hundreds of years, locally influencing soil properties, and increasing surface and subsurface variation. For example, fallen branches and trees create dimpled surfaces that harvest stormwater runoff and become important regeneration substrates for seedlings above the forest floor or wetland watertable. Podocarps (and kauri) are linked to soil acidification; many native plants are tolerant of elevated aluminium linked with pH <5, advantaging them over many non-native plants (notably legumes). 'Standard' pastoral pHs above 5.5 to 6 remove this advantage. Small-scale spatial heterogeneity of depth and topography can be critical to enhance resilience of native ecosystems to drought or waterlogging, particularly as native restoration is rarely irrigated. Variation across larger scales is also important where a range of ecosystems or flowering/fruiting times is valued. In this paper we use examples from ecosystem rehabilitation to suggest appropriate soil quality measures. We suggest these 'indigenous' measures are used for restoration projects, and replace current criteria used in many road projects (e.g. NZ Transport Authority P39 specification). We also show methods of treating agricultural and earth-worked soils to underpin resilient native ecosystems.

The Tea Bag Index and Soil Carbon Cycling

Robert Simpson[1], Irene Setiawan[1], Karen Mason[1], Karin Müller[2]
[1]*Plant & Food Research, Palmerston North, New Zealand,*
[2]*Plant & Food Research, Ruakura, New Zealand*

The Tea Bag Index (TBI; Keuskamp et al., 2013) has been developed as decomposition reference, with the aim to create a global map of decomposition rates and determine relations between environment and decomposition potential at a global scale. In brief, the TBI uses two types of teabags with contrasting degradability (green and rooibos) buried for three months to assess carbon stabilisation and utilisation. Adding carbon sources to soil can alter microbial activity and carbon storage, which may bias TBI results by enhancing the decomposition of soil carbon or increasing carbon storage through the accumulation of freshly-fixed carbon. This study examined the effect of adding tea bags on soil carbon cycling and microbial populations. Tea bags were buried in a maize (Zea mays L.) field in mid-November 2017. The tea bags and surrounding soil were removed at regular intervals up to 120 days after burial. The weight of the remaining tea, hot and cold water extractable carbon, microbial biomass and the extracellular enzyme activities β-glucosidase, β-galactosidase, xylanase, chitinase, tyrosinase, peroxidase, phosphatase and sulfatase were measured. Soil around rooibos tea bags was similar to soil around control burials in all parameters analysed. In contrast, glycosidase activity in soil around green bags increased significantly after 16 days, peaking between 28 and 42 days before slowly declining. The greatest change was observed for β-galactosidase with activities being more than sixty times higher that measured in control soil. Cold water carbon, and to a lesser extent, hot water carbon showed similar patterns, while for microbial biomass and other enzyme activities no clear trends were observed. These results confirm that adding a carbon source to soil will alter the microbial activity. However, this alteration is unlikely to effect the TBI as it is independent of the rate of green tea degradation.

Optimising forest productivity, soil nutrient pools and environmental outcomes with NuBalM

Simeon Smaill[1], Loretta Garrett[2], Peter Beets[2], Peter Clinton[1]
[1]*Scion, Christchurch, New Zealand,* [2]*Scion, Rotorua, New Zealand*

The long term impacts of forest management practices on soil nutrient pools and dynamics are critical to the sustainability of the New Zealand planted forest estate. One third of planted forests are on soils that are nutrient deficient, and much of the remainder of the estate is on soils that are only marginally better. Despite these soil nutrition issues, the use of fertiliser is minimal due uncertainty around financial returns. The forest nutrient balance model "NuBalM" was developed to address these issues, facilitating a balance between productivity and the sustainable management of forest soil and ecosystem nutrient pools. NuBalM satisfactorily predicted stem wood production based on soil nitrogen supply and demand from multiple trial sites examining variations in stocking, thinning and fertiliser regimes (mean underestimate of 1.1±1.0 Mg ha−1, 95% CI, n = 92). Using NuBalM to explore differences in organic matter removal at harvest and site establishment generated acceptable estimates of stem mass (mean overestimate of 5.5±7.4 Mg ha−1, 95% CI, n = 6) and total nitrogen pools (mean overestimate of 52±53 kg N ha−1, 95% CI, n = 9). NuBalM is now being used to predict the nitrogen gap required to increase productivity to target values at specific sites (e.g. 500 kg N ha-1 over several years to increase stem mass by 32%), and the impacts of intensive harvesting on soil nutrient pools over multiple rotations (worst case management for 120 years reduced soil nitrogen pools by 81-84% and productivity by 75-77%). NuBalM is linked to a forest carbon accumulation model, and can be readily extended to simulate the growth of other trees species. We seek to engage with the soil science community regarding the NuBalM platform, as it has considerable potential to support the effective establishment and management of tree plantings under the One Billion Trees initiative.

Project-based learning and soil judging: approaches to teaching the “hidden skills” in Soil Science.

Dr Carol Smith[1], Dr Henry Chau[1], Helen Gilmore[1], Judith van Dijk[1], Dr Sam Carrick[5]
[1]*Lincoln University, Lincoln, Christchurch, New Zealand,*
[5]*Mannaki Whenua - Landcare Research, Lincoln, Christchurch, New Zealand*

Soil scientists are increasingly working in a multidisciplinary world where they interact with professionals from different disciplines and diverse end user groups. The ability to communicate, critically appraise, problem solve, and to be an effective team player are as important skills as the ability to describe soil profiles. The kinaesthetic approach embodied in soil judging allows the student to also connect with pedological theory; we posit that it is a pedagogically-aligned style of learning.

At Lincoln University, we have adopted two approaches to address these issues. We have developed a 300 level course (advanced field research) which utilises project-based learning. The students form multidisciplinary groups. They choose a real world environmental “problem”, and design a research project to investigate the issue. Group work involves experimental design, data collection and analysis, plus communication of results. The groups “learn by doing”. Students are assessed on practical skills testing, report writing, reflective journal and presentation / communication skills. Students reported an increase in a diverse skill set: communication, critical reflection, teamwork and problem-solving skills.

Soil judging in New Zealand is in its infancy compared to other countries, but the undergraduate student soil science society and academic staff have been enthusiastic in practicing soil description skills and have participated at a range of soil judging contests. Students report that they have become more confident in soil description and that it has stimulated their interest in learning about soil science. It may also be an effective recruitment pipeline into the discipline: offering those students with practical and kinaesthetic aptitudes who perform well at soil judging an insight into the academic side of the soil science discipline. Both project based learning and soil judging are effective tools for students to acquire a valuable range of skills for a professional career in soil science or allied enterprises.

Using recycled glass to increase P availability of insoluble Dorowa phosphate rock

Akinson Tumbure[1], Michael Bretherton[1], Peter Bishop[1], Michael Hedley[1]
[1]*Institute of Agriculture & Environment, Massey University , Palmerston North, New Zealand*

Innovative use of recycled glass to improve phosphorus solubility of otherwise insoluble Dorowa phosphate rock can be a more economical and environmentally friendly alternative to produce phosphate fertilisers. The effect of structural and mineralogical alteration of Dorowa PR when sintered with recycled glass in ratios of 1:1, 1:2 and 2:1 (Dorowa PR: glass) was assessed in comparison to sintering with serpentine and dunite. Sintering was performed at 900 and 1000 °C and the product was either slowly air cooled or rapidly cooled in ice water. The final products had a minimal reduction in mass after sintering (less than 0.1%) indicating that there were no major losses of the product. Compared to 1000 °C, sintering at 900 °C was generally better in improving citric acid soluble P and recycled glass, serpentine and dunite had resultant citric solubilities of 39.5%, 42.2% and 36.6% (mixing ratio of 1:2 (DPR:glass). Water quenching was only significant in improving the citric solubility of the serpentine:DPR (1:1) sintered product from 19.5 % to 28.9%. These results show that recycled glass can be used to improve the citric acid solubility of non-reactive igneous rocks such as Dorowa PR to levels comparable to directly applied reactive sedimentary PR. Improvement of citric solubility is because of alteration of the crystal structure of apatite minerals through possible isomorphous substitution of PO_4^{3-} by SiO_4^{4-}. We also conclude that water quenching is not necessary to stop formation of insoluble crystals upon cooling except when serpentine is used in the ratio 1:1.

Innovative cadmium (Cd) electrode to quantify soil and plant Cd species

Mrs Nilusha Ubeynarayana[1], Dr Peter Bishop[1], Dr Paramsothy Jeyakumar[1], Dr Roberto Pereira[1], Professor Christopher Anderson[1]

[1]*Fertilizer & Lime Research Centre, Environmental Sciences, School of Agriculture & Environment, Massey University, Palmerston North, New Zealand*

Elevated levels of cadmium (Cd) concentration in New Zealand's agricultural soil is strongly related with the long-term high application rate of Cd-contaminated phosphate fertilisers. This hinders their use for the cultivation of high-value pasture and food crops within the New Zealand Agricultural system. Although Cd is considered to be a non-essential element for plants, it is effectively absorbed by the root systems of many plants. Recent studies have revealed that some forage species accumulate more Cd than other species which suggests the different abilities of plant species to either absorb Cd from soils or to translocate Cd from root to shoot. The uptake mechanism of Cd in different plant species requires the quantification of the forms of Cd, free Cd2+ ion and Cd complexed with different organic and inorganic compounds in xylem sap. The isolation of the different Cd species in the xylem sap can be achieved using advanced separation techniques such as gel exclusion and high performance liquid chromatogaraphy. The low concentrations of Cd species in the xylem sap pose an analytical challenge, however in recent years electrochemical methods such as stripping voltammetry (SV) using selective working electrode materials have reduced the cost and complexity of sample preparation. The development of chemically modified carbon paste working electrodes have attracted much attention in this field with scope for innovation.

Quantitative and qualitative properties of dissolved organic matter and their relationship with biodegradability

Tihana Vujinović[1,2], Timothy J. Clough[1], Denis Curtin[2], Niklas J. Lehto[1], Michael H. Beare[2]

[1]*Lincoln University, Lincoln, New Zealand,* [2]*Plant & Food Research, Lincoln, New Zealand*

Despite representing <2% of the total soil organic matter, dissolved organic matter (DOM) is the most mobile and reactive source of mineralizable carbon and nitrogen for plant growth and microbial activity. However, there is limited understanding of the mechanisms and the factors determining DOM's concentration, chemical quality and its mineralization potential (i.e. biodegradability), including the mineralization response to land use change. Our study investigated the effects of land management on the quantitative and qualitative properties of different DOM fractions and examined their relationship with DOM biodegradability. Soils were collected from a long-term field trial that consisted of three land management treatments: a permanent pasture, a no-tillage arable cropping rotation and a chemical "fallow". Cold (CW) and hot (HW) water extractions were performed to recover different fractions of soluble organic matter. Each CW and HW extract was treated with an anionic exchange resin to discriminate DOM according to its polarity. Up to 67% and 86% of the DOM extracted with CW and HW, respectively, was removed by the resin treatment, regardless of land management treatment. Fluorescence fingerprints and specific ultraviolet absorbance at 254 nm ($SUVA_{254}$) revealed the structurally complex and aromatic nature of the polar fraction of DOM retained by the resin, in contrast to the recently produced, possibly microbially-derived, aliphatic constituents of the non-polar fraction. While the latter (low $SUVA_{254}$ values) were associated with higher biodegradability of the CW-DOC, there was no such relationship in the HW extracts. There was a significant effect of land management on DOC and DON concentrations in the CW extracts, whereas only DON was significantly affected in the HW extracts.

Does imported supplemental feed to a dairy farm result in an increase in soil carbon?

Aaron Wall[1], Dave Campbell[1], Paul Mudge[2], Louis Schipper[1]
[1]University Of Waikato, Hamilton, New Zealand, [2]Manaaki Whenua - Landcare Research, Hamilton, New Zealand

Both the usage and importation of supplemental feed to dairy farms has increased significantly in the past 20 years. Increased importation is suggested to lead to an increase in soil carbon (C) stocks, while also increasing milk production. We measured the net ecosystem carbon balance (NECB; considered analogous to the change in soil C) of a commercial dairy farm in the Waikato which imported ~12 t DM ha-1 y-1 (~5.3 t C ha-1 y-1), constituting 43% of the cows diet, for three years.

The NECB method couples measurements of CO2 exchange between the atmosphere and ecosystem with measurements of all imports and exports of carbon from the farm. The CO2 exchange was measured using the eddy covariance technique. Imports of carbon included supplemental feed and fertiliser, while exports included respiration, methane and milk produced from ingested feed (pasture and supplemental) by the grazing cows, along with leaching and any emissions from the effluent storage ponds.

Positive NECB's (representing a gain in soil C) were determined for all three years (1.31 ± 0.76, 0.35 ± 0.65 and 0.48 ± 0.81 t C ha-1 yr-1 respectively) resulting in an average gain of 0.71 ± 0.74 t C ha-1 yr-1. Despite the importation of large quantities of supplemental feed resulting in increased C in the system, only a small gain in soil C was measured (equivalent to 13% of imported feed). The magnitude of the gain was similar to predicted gains from both scenario modelling for the level of feed imported, and stabilisation of C in the excreta generated from the imported supplemental feed. However, this gain may be offset during the production of the supplemental feed, an aspect which is being investigated in an aligned study.

Amendment incorporation to increase soil water retention of shallow stony soils

Dirk Wallace[1], Peter Almond[2], Steve Thomas[1], Sam Carrick[3], Nick Pyke[4]
[1]Plant & Food Research, Lincoln, New Zealand, [2]Lincoln University, Lincoln, New Zealand, [3]Maanki Whenua Landcare Research, Lincoln, New Zealand, [4]Foundation for Arable Research, Templeton , New Zealand

Much of New Zealand's current irrigation expansion is onto highly permeable, shallow stony soils with low water retention. These characteristics combine to make these soils vulnerable to leaching of nutrients and drainage of excess irrigation water. To maximise the benefits of irrigation on these soils, a management practice is required that maximises their ability to retain irrigation water for plant growth without losing it to drainage, runoff or evaporation. Increasing the water-retaining capacity of these soils would have both economic (production and reduced irrigation costs) and environmental (reduced nitrate leaching) benefits for these vulnerable soils.

One potential solution is to incorporate a soil amendment to target an increased water retention and/or reduced water losses. An experiment was designed to investigate the effects of incorporating three different amendments: municipal compost (150 t ha^{-1}), sphagnum moss (18 t ha^{-1}), polyacrylamide gel (3 t ha^{-1}) compared with an un-amended control, on water retention and movement under two rates of spray irrigation, 10 mm h^{-1} and 80 mm h^{-1}. Each amendment was incorporated into 32 lysimeters which simulated a typical shallow stony soil. The lysimeters were planted in Italian rye-grass and managed to standard practices.

Incorporation of sphagnum moss produced the greatest increase in soil water retention, followed by municipal compost and polyacrylamide ($p<0.001$). This increase was driven by an increase in the volume of mesopores, from the creation of new inter- and intra-particle pore spaces and an increase in soil volume. Irrigation rate did not affect soil water retention; however, increasing irrigation rate resulted in a proportional increase in infiltration rate ($p<0.001$) and drainage amount ($p<0.001$). The increase in water retention due to amendment incorporation resulted in prolonged plant water use under non-irrigated conditions ($p=0.046$). The implications of these results on irrigation scheduling and potential water savings are also discussed.

The science behind ‘Terroir’

Mark Shepherd[2], **Professor Andrew Waterhouse**[1]
[1]University of California, [2]Agresearch

Terroir is an important concept in viticulture and can be defined as the characteristic taste and flavour imparted to a wine by the environment (including factors such as the soil, topography, climate, microbiology and human factors) in which it is produced. The Hawkes Bay wine producing region, with its contrasting soils and landscapes, provides an excellent backdrop to discuss Terroir.

In this presentation, we will describe the soils of Hawkes Bay and the implications for wine growing and provide a review of the science behind the concept of Terroir of wine grapes, otherwise known by the pedestrian term, “site”.

Furthermore, we will consider if the concept of Terroir is transferable to other New Zealand food products. The geographic origin of other traditional foods, such as cheese, meat, and honey, is also recognized in Europe. If this could more broadly applied in New Zealand, the concept could be used to define particular high quality sources of particular foods (as with Manuka honey); this would sit well in a future where discerning consumers value specific quality traits as well as the backstory of where and how a food was produced.

Bottom-up or top-down? Paddock-scale nitrous oxide budgets using static chamber and eddy covariance data

Anne Wecking[1], Liyin Liang[2], David Campbell[1], Stuart Lindsey[3], Jiafa Luo[3], Aaron Wall[1], Louis Schipper[1]
[1]University of Waikato, Hamilton 3216, New Zealand, [2]Manaaki Whenua Landcare Research, Hamilton 3240, New Zealand, [3]AgResearch Ruakura, Hamilton 3214, New Zealand

Soils under pastoral land utilised for dairy and meat production are a major source of the greenhouse gas nitrous oxide (N2O). In New Zealand, N2O contributes ~10.5% (carbon dioxide equivalents) to the domestic gross emission profile. To date, quantification and budgeting of N2O emissions from soils require the use of emission factors that are based on chamber measurements. Data derived from these chambers are commonly used to build greenhouse gas inventories in New Zealand and elsewhere by extrapolation from point to national scales but often do not include a continuous data coverage. Recent advances in detector technology now offer the ability to measure N2O fluxes over larger spatial and temporal scales when coupled with the eddy covariance technique. In November 2016, an eddy covariance tower measuring N2O fluxes was established on a New Zealand dairy farm with year-round grazing. Using a quantum cascade laser absorption spectrometer (QCL-AS, Aerodyne), the eddy covariance system quantified the concentration of N2O, methane and water vapour simultaneously at 10 Hz over an area of 6 ha. Eddy covariance measurements were aligned with static chamber measurements during two field campaigns in mid-spring 2018 and 2019. The first campaign provided site-specific emission factors for dairy cattle urine (540 kg N ha-1), dairy cattle dung (1132 kg N ha-1) and urea fertiliser (50 kg N ha 1) on a ryegrass-clover sward of 1.53%, 0.24% and 0.17%, respectively. Emission factors were used to quantify N2O budgets by using the New Zealand inventory methodology. Here, we report first results of these chamber derived N2O budgets in comparison with those from the eddy covariance systems. Results will advance the New Zealand greenhouse inventory but may also significantly improve our current understanding of N2O emissions and controlling factors from the point to the paddock scale.

Cadmium sorption and mobilization by organic soil amendments

Dharshika Welikala[1], Niklas Lehto[1], Cameron Hucker[1], Adam Hartland[2], Brett Robinson[3]
[1]Department of Soil and Physical Sciences, Lincoln University, Christchurch, New Zealand, [2]Environmental Research Institute, School of Science, University of Waikato, Hamilton, New Zealand, [3]School of Physical and Chemical Sciences, University of Canterbury, Christchurch, New Zealand

Accumulation of cadmium (Cd) in soils worldwide has increased the demand for sustainable methods to reduce its transfer to terrestrial and aquatic food chains. Organic amendments have shown great potential for increasing soils' capacity to bind Cd, thus reducing its availability for plant uptake. However, the dissolved organic matter (DOM) released from organic amendments may enhance the mobility of Cd. The extent of this mobilisation is determined by a combination of the ease with which the complex can dissociate, as well as the resistance of the complexing DOM against biodegradation. In this study, we evaluated the Cd binding capacities of ten different organic soil amendments, including composts, biosolids and peats. The soil amendments bound Cd successfully with different binding capacities ranging from 7 to 1717 L kg-1. We then selected two composts and two types of peats to compare their Cd binding affinities with respect to nickel (Ni) and zinc (Zn). The results revealed that the amendments generally bound more Cd than Ni and Zn. We also tested the lability of metal-DOM complexes of Cd, Ni and Zn released by these amendments, using an adapted diffusive gradients in thin-films (DGT) device and characterised the DOM released from the different amendments with fluorescence excitation-emission matrices. The preferential binding of Cd may be due to the different functional groups present in the organic amendments such as reduced organic sulphur containing groups (soft Lewis base) which can show a strong affinity for Cd (soft Lewis acid) over Ni or Zn (intermediate Lewis acid). We found that the Cd-DOM complexes released from the peats were more labile than those released from the composts. The aromatic characteristics of DOM complexes appear to be an important factor in determining the lability of metal-DOM complexes formed by Ni and Zn but to a lesser extent for Cd.

Effects of different irrigation regimes on growth and water use efficiency in Populus tomentosa plantations

Dr Benye Xi[1], Ms Doudou Li[1], Mr Jinqiang Liu[1], Ms Nan Di[1], Dr Mark Bloomberg[2], Dr. Liming Jia[1]
[1]Ministry of Education Key Laboratory of Silviculture and Conservation, Beijing Forestry University, Beijing , China, [2]School of Forestry, University of Canterbury, Christchurch, New Zealand

For establishing high-efficiency irrigation regime for short-rotation Populus tomentosa plantations on the North China Plain, an irrigation experiment was initiated in 2016 when the tree was 2-years-old. Two drip (DI), two border (BI) and one control irrigation (CK) treatments were included in this experiment, which was a randomized block design with four replications. In the DI treatments, trees were irrigated when the soil water potential at 20 cm depth beneath the dripper reached -20 (DIFI) and -45 kPa (DICI), respectively. In the BI treatments, irrigation was applied every 5-7 (BIFI) and 30 days (BICI), respectively. Trees in CK were only irrigated once at leaf-out stage. According to the results in 2016, the irrigation amounts (IA) among treatments varied hugely, with 276, 61, 1406, 384 and 49 mm in DIFI, DICI, BIFI, BICI and CK, respectively. Among treatments, annual tree height increment and average leaf area index were not significant, but the annual diameter (DBH) and area at breast height (ABH) increments were significant ($P<0.05$). Maximum ABH growth was observed in the DIFI, which was 19% and 27% significantly higher ($P<0.05$) than the DICI and CK treatments, but only slightly higher (6%) the BI treatments. Evapotranspiration varied from 341 to 428 mm in different treatments, with the minimum observed in the DIFI treatment. Irrigation water use efficiency (ABH increment/IA, IWUE) decreased with increasing IA as a power function, while ABH increment and transpiration water use efficiency (transpiration/IA, TWUE) increased and then decreased with increasing IA. The TWUE of DIFI (0.224 cm2/mm) was 20%-100% higher than other treatments. In conclusion, for the 2-years-old plantations, the DIFI treatment brought the highest benefits: saving 28%-80% irrigation water relative to the traditional BI regimes, consuming 3%-20% less water than other treatments, and having the highest growth rate and TWUE and medium IWUE.

Beneficial use of biosolids to forestland: What are the environmental impacts?

Jianming Xue[1], Mark Kimberley[2], Minghuang Wang[1], Gerty Gielen[2], Louis Tremblay[3], Olivier Champeau[3], Craig Ross[4], Jacqui Horswell[5]

[1]Scion, Christchurch, New Zealand, [2]Scion, Rotorua, New Zealand, [3]Cawthron Institute, Nelson, New Zealand, [4]Landcare, Palmerston North, New Zealand, [5]ESR, Porirua, Wellington, New Zealand

Biosolids, rich in organic carbon and nutrients, are commonly used as soil amendments on cropland, and preferably on forestland in New Zealand. However, few studies have examined the environmental impacts of biosolids application on forestland in ecologically based long-term studies. This study investigated the impact on soil and groundwater quality, tree nutrition and growth, and wood quality of long-term biosolids application to a radiata pine plantation forest growing on a poor soil at Rabbit Island in Nelson, New Zealand. Biosolids have been applied to the trial site every three years from 1997 to 2012 at three application rates: 0 (Control), 300 (Standard) and 600 (High) kg N ha-1. Tree nutrition and growth were monitored annually, soil properties every three years, and groundwater quality quarterly. Both the Standard and High biosolids treatments significantly increased soil total C, N and P, Olsen P, and reduced soil pH at 0-50 cm, and increased soil total N at 50-75 cm. The High biosolids treatment also increased concentrations of soil total Cr at 0-25 cm, and Zn at 25-50 cm, but they were considered very low for a soil. Ecotoxicological assessment showed no significant adverse effects of biosolids application on springtails reproduction and soil microbial biomass. Biosolids application significantly increased foliar N concentration and tree stem volume growth. Wood density was slightly reduced by biosolids application. The electrical conductivity and the concentrations of Cu, Cr and Zn of groundwater appeared to increase slightly over the period of biosolids application. We concluded that repeated application of biosolids to a plantation forest on a poor site could significantly improve soil fertility, tree nutrition and site productivity without causing significant adverse impact on the receiving environment. However, the long-term fate of biosolids-derived heavy metals and organic pollutants in the receiving environment needs to be further monitored.

The bioavailability of cadmium in New Zealand cropping soils

Zicheng Yi[1], Niklas Lehto[1], Brett Robinson[2], Jo-Anne Cavanagh[3]

[1]Lincoln University, Christchurch, New Zealand, [2]University of Canterbury, Christchurch, New Zealand, [3]Landcare Research, Christchurch, New Zealand

Cadmium (Cd) accumulation in agricultural soils is a global issue, because its transfer to edible parts of common crop plants can pose a risk to the food security of consumers. However, efforts to predict and mitigate the risks posed by soil Cd are often confounded by the large variety of factors that influence the bioavailability of the metal. The objective of this work is to improve the understanding of the key drivers that determine Cd bioavailability to plants grown under normal agricultural management practices.

We undertook a nationwide survey of 100+ farms that grow spinach, onion, potato and wheat around NZ. We collected paired soil and plant samples, and measured the total Cd concentrations in the edible plant parts and analysed the soils using different methods to test the bioavailability of the Cd (pseudo-total and porewater concentrations, 0.05 M Ca(NO3)2-extraction and diffusive gradients in thin-films, DGT). We also collected information on a variety of soil and climatic variables. We then compared the methods' ability to predict the Cd concentrations in the various plant samples.

The pseudo-total soil Cd concentrations varied between 0.017 - 1.353 mg·kg-1, while the plant Cd concentrations ranged between 0.009 and 2.238 mg·kg-1 DW. The bioavailability testing showed that the predictive capability of these four methods varied between plants, with no single test providing an adequate prediction for all four species. We then used multivariate regression analysis to show that, once certain soil and climatic variables were accounted for, Ca(NO3)2 extractions could provide a satisfactory prediction of Cd uptake by onions and wheat, while DGT provided the best estimate for potatoes and spinach. Our results indicate that various environmental factors can combine to determine the uptake of Cd by different crop species and should be considered when estimating the risks posed by Cd in agricultural soils.

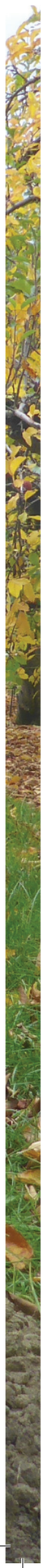
Characterisation of macropores and preferential flow of mountainous forest soils with different human disturbance intensities

Jun Yi[1], Muxing Liu[1], Wei Hu[2], Mike Beare[2]
[1]Central China Normal University, Wuhan, China, [2]New Zealand Institute for Plant & Food Research Limited, Christchurch, New Zealand

Preferential flow can develop in soil macropores which are sensitive to human disturbance. The study aimed to investigate soil macropore features and the main factors controlling preferential flow at four sites with different levels of human disturbance intensities in a mountainous area in Central China. The level of human disturbance decreased with increasing elevation with the lowest areas covered with coniferous trees (LF) > middle mountain areas covered with tea gardens (TG) > middle mountain areas covered with deciduous trees and mixed shrubs (MF) > subalpine areas covered with evergreen coniferous trees (HF). At each site, soil pore structure of the 0–40 cm soil depth was analysed using computed tomography (CT) scans. Preferential flow was determined using the breakthrough curve (BTC) with nitrate. The macroporosities of LF, TG, MF, and HF were 1.6%, 3.8%, 9.3% and 11.3%, respectively, and the corresponding number density of macropores were 0.23, 0.40, 0.73, and 1.00/cm2, respectively. This indicated that human disturbance accelerated the damage of soil pore structure. Less human disturbances corresponded to the stronger evidence of preferential flow as indicated by fast breakthroughs, long tails, and asymmetry of BTCs. A mobile-immobile model (MIM) can be used to simulate soil water flow in sites with much macropores (e.g., MF and HF), whereas the convection-dispersion equation (CDE) was more suitable for the TG and LF. More macropores at the HF, MF and LF sites corresponded higher v, vm, D, and Dm values compared to the LF sites, whereas few differences in λ (λeff) were identified among the four sites. This study indicated that human disturbance should be minimised to maintain macropore structure and decrease the risk of natural disaster of flooding, soil erosion, and non-point source pollution to the receiving water body like Yangtze River.

POSTER ABSTRACTS

In order of presenters last name



Can soil carbon extracts be used to culture subsamples of soil microbiota for mini-metagenomics?

Craig Anderson[1], Michelle Peterson[1], Rebekah Frampton[1], Denis Curtin[1]
[1]*Plant & Food Research, Lincoln, New Zealand*

Estimates suggest that >99% of microorganisms in soil remain uncultured. Here we describe a methodology to cultivate functionally important subsamples of soil microbial diversity using environmentally relevant carbon sources.
Minimal salts media was supplemented with filter-sterilised soil-C extracted from 3 chemically distinct soils using cold water, hot water or dilute alkali. Inoculums were harvested from soil slurries, diluted 10-fold, with the lowest inoculation being 1 cell per well. Plates were incubated for one month and cell growth calculated by MPN. DNA was extracted from the original soil and from cultures pooled across dilutions. 16S rRNA and ITS amplicons were sequenced to assess differences in communities utilising soil-C compared to glucose.
Only 1% of the soil microbial biomass (2.8 x 10^8 cells/g) was harvested, with 75-80% live. Neither Soil-C source nor extraction method affected MPN, but glucose MPN was 9-fold lower than soil-C MPN. Cultured OTUs represented 9% of the soil OTU diversity (1040 versus 11300 OTUs respectively) with Proteobacteria and Bacteroidetes dominating the cultures at 43 and 27% respectively, compared to 30 and 16% in the soil microbiome. Acidobacteria representation was 10% in the soil microbiome but only 0.9% in the cultured sub-sample while Firmicutes dropped from 5 to 2%.
As inoculum was diluted more diverse organisms were cultured and although common genera (e.g. Pseudomonas) were easily isolated, others such as Bacillus were underrepresented. This suggests that the harvest methodology skews results and requires changes to expand sub-sample diversity. However, this method is a viable way to reduce bacterial community complexity and would allow mini-metagenomes and metabolic profiles to be constructed especially if coupled with mass-spectrometry to determine carbon use patterns in community subsets. Using soil-C extracts, we estimate that the diversity of microbes cultivated using a soil-C methodology could be at least 10-fold greater than current cultivation methods.

Catch crops reduce the risk of nitrogen leaching after summer cropping in the Waikato

Nathan Arnold[1], A Hunt[1], F Liu[1], I Sorensen[1], S McDougall[3], M Parker[2], B Malcolm[1], P Johnstone[1]
[1]*The New Zealand Institute for Plant & Food Research Limited,* [2]*Foundation for Arable Research,* [3]*Foundation for Arable Research*

Nitrogen (N) leaching losses require careful consideration because of the related risks to surface and ground water quality. In New Zealand, the greatest risk is usually during the months of winter and early spring when drainage events are more common. This period coincides with the harvest of summer crops, or grazing of autumn forage crops which can contribute to N loading. Under these production systems there is often risk of N leaching losses as fields typically remain fallow for several months after summer cropping or winter grazing.
Two field trials investigated the potential benefit of establishing a winter catch crop to reduce residual mineral N compared a fallow control. Catch crops included oats and Italian ryegrass in years 1 (2016) and 2 (2017) and triticale year 2 (2017). All plots received simulated urine deposition (400 kg N/ha as urea). Catch crops were established on three sowing dates (March, April and May, both years). In each year a fallow control was established and maintained weed free using herbicides. Changes in soil mineral N (0-90 cm depth) and biomass production were assessed throughout the duration of the experiments.
Results for the trials will be summarised in the presentation. Key messages include: 1) early planting increases the amount of residual soil N taken up by the catch crop and therefore the reduction in leaching risk; and 2) cereal catch crops tended to perform better than Italian ryegrass in terms of the amount of biomass accumulated and therefore N uptake. All treatments were more effective than the fallow control in reducing residual soil N, albeit in late sown combinations the benefit was modest during the high risk winter period.

Effects of placement and application rate on retention of crop residue carbon and nitrogen

Mike Beare[1], Edward Gregorich[2], Bobbi Helgason[3], Denis Curtin[1], Craig Tregurtha[1], Henry Janzen[4], Ben Ellert[4]
[1]Plant & Food Research, Lincoln, New Zealand, [2]Agriculture & Agri-Food Canada, Ottawa, Canada, [3]Agriculture & Agri-Food Canada, Saskatoon, Canada, [4]Agriculture & Agri-Food Canada, Lethbridge, Canada

Post-harvest crop residues are an important resource for arable farmers because they add organic matter to the soil and re-cycle plant nutrients. Decay of plant residues is tied to many ecosystem functions, affecting atmospheric CO2, microbial diversity, soil organic matter quality, among others. The rate of decay, in turn, is governed by soil type and management, location in the soil profile, and environmental variables, some of which may be changing in the coming decades. Our objective in this study was to elucidate the decomposition dynamics of plant-derived C when two rates of residue were applied either at the soil surface or incorporated into the soil. To do this we established a long-term study at a site in Lincoln, New Zealand. We applied 13C-labelled barley straw (13C = 10.2 atom%; C = 37.9%; N = 0.95%; C:N = 40) at two rates equivalent to 2 and 4 Mg/ha. Soil water content and temperature were logged over the experimental period. Soil samples were collected at 7 times over 6 years. Substantial decomposition occurred in a short time (< 1 year), even deeper in the soil profile. After 6 years, 83% residue C was lost in surface 10-cm layer. Over time, the amount of residue N retained was relatively greater than C; this effect was greater where residue was mixed into soil. Depth of placement affected the concentration of viable microbes but the size of the microbial population did not appear to limit decomposition.

Facilitating collaborative research through the New Zealand – China Water Research Centre

Sam Carrick[1], Hong Di[2], Jiafa Luo[6], Blair Miller[3], Keith Cameron[2], Paul Johnstone[4], Wenhua Wei[6], Henry Chau[2]
[1]Manaaki Whenua, Lincoln, New Zealand, [2]Lincoln University, Lincoln, New Zealand, [3]Lincoln Agritech, Lincoln, New Zealand, [4]Plant & Food Research, Havelock North, New Zealand, [5]AgResearch, Ruakura, New Zealand, [6]University of Otago, Dunedin, New Zealand

Water quality and quantity issues, such as ground and surface water contamination by agrichemicals and poor water use efficiency of irrigation, are common both in China and New Zealand. The aim of the New Zealand – China Water Research Centre (NZCWRC) is to coordinate and facilitate long-term collaborations between New Zealand and Chinese scientists from a broad range of organisations, and to develop coherent research strategies that relate to water quality and quantity issues in the two countries. The New Zealand – China Water Research Centre is hosted by Lincoln University, in partnership with AgResearch, Plant & Food Research, Lincoln Agritech Ltd, Manaaki Whenua -Landcare Research, and University of Otago. The objectives of the centre include:

- To coordinate collaborations between New Zealand and Chinese scientists from multiple organisations to mitigate water contamination, safeguard water quality, and increase water use efficiency.
- To develop enduring partnerships between New Zealand and Chinese scientists on water quality and quantity research.
- To create new knowledge and novel solutions on water quality and quantity issues.
- To increase cultural understanding, enhance Māori engagement with China, and promote New Zealand as a centre of excellence in research and development in water quality and quantity for high quality food production.

Activities of the New Zealand - China Water Research Centre can be viewed at https://www.crcc.nz/water-research, with a busy first two years for members undertaking several scoping visits to China and hosting a two-day workshop in Lincoln attended by over 60 researchers from 18 Chinese institutions and nine New Zealand institutions. Strong and broad connections have been established with China research institutions and scientists, and we are most willing to pass these onto New Zealand scientists and industries interested in working with Chinese researchers.

Soil matric potential effects on soil oxygen, redox, N2O production and isotopic composition.

Tim Clough[1], Benjamin Wolf[2], Klaus Butterbach-bahl[2], Ralf Kiese[2]
[1]Lincoln University, [2]Karlsruhe Institute of Technology (KIT), Institute of Meteorology and Climate Research, Atmospheric Environmental Research, Germany

Functional soil pore space, measured as relative gas diffusivity (Dp/Do) has been shown to relate strongly to N2O fluxes from soil exposed to both nitrate and urea, with strong log-N2O flux vs log Dp/Do relationships. Such relationships have, recently, also been observed in situ. The variable Dp/Do performs better than other commonly used physical measures such as water-filled pore space because it accounts for the functional diffusive pathways in the soil that permit O2 entry and/or N2O release. Given that N2O production mechanisms and N2O reductase are strongly influenced by O2 supply, it is very likely that a measure of Dp/Do could also indicate the likely production pathways or fate of N2O in pasture soils. Here we present initial data from laboratory studies using repacked soil cores that examines the role of soil moisture (matric potential) in altering soil oxygen status, redox status, N2O flux production. Also presented are the first initial measurements of soil evolved N2O isotopomer measurements made from soil cores held at varying matric potential. Implications for using such data to better understand the production and fate of N2O in the soil will be discussed.

Surface-water nutrient quantification and the linkages to land-use: enhancement of 'diffusive gradients in thin-films' methodology

Thomas Corbett[1], Professor Louis Schipper[1], Dr Adam Hartland[1], Professor William Henderson[1], Gerald Rys[2]
[1]Waikato University, Hamilton, New Zealand, [2]Ministry for Primary Industries, Wellington, New Zealand

Primary industries rely on finite biological and physical resources, the sustained long-term use of which is dependent upon our understanding of how these might be appropriately utilised and managed. Land management decisions can have significant impacts on water quality through nutrient run-off and leaching. To understand this relationship more clearly, and identify opportunities for mitigation, this study seeks to test diffusive gradients in thin-films (DGT) for the measurement of nitrate/nitrite and phosphate, and furthermore enhance this methodology so that in-field analysis may be undertaken. DGTs overcomes the major limitations of grab sampling, the current measurement technique, by addressing the high variability of nitrate/nitrite and phosphate. DGTs provide time integrated concentration data and are inexpensive. Measuring long-term averages of nutrient concentrations would enable land users to make environmentally sound management decisions; for example, where intensification can occur sustainably. This study will develop a nitrate/nitrite and phosphate sensor based on the DGT technique incorporating a simple colour change; thereby creating a measurement tool that is easy to use, accurate, and inexpensive.

The influence of artificial subsurface drainage on soil hydraulic properties

Kirstin Ella Deuss[1], Peter Almond[1], Sam Carrick[2]
[1]Lincoln University, Lincoln 7647, New Zealand, [2]Landcare Research, Lincoln 7640, New Zealand

Soils have an inherent capacity to regulate water storage and redistribution in the landscape. Understanding the processes involved in soil water regulation is key to providing relevant, accurate and reliable information on soil hydraulic properties, however a research gap remains on the response of these properties to land management practices. Subsurface drainage systems have played a pervasive role in the history of land development in Southland and are now widespread throughout the regions' agricultural landscapes. Little is known about the influence this management practice has on the physical and hydraulic parameters of soils, and to what scale and magnitude this influence is exerted.

This research will shed light into the processes involved in the storage and movement of water through mole and tile drained soils. Insight into the spatial and temporal fluxes will be provided by examining the relationship between precipitation characteristics and soil moisture response. A comprehensive monitoring network is being set up to record lag times, soil moisture content and soil water chemistry within a four-hectare hydrologically isolated sub-catchment in Otahuti, Southland. Ground penetrating radar (GPR) was used to identify mole channels which were confirmed to be in remarkably good condition despite their age of 30+ years. High densities and multiple patterns of mole channels were mapped using GPR, indicating successive generations of ploughing and an extensive network of subsurface drainage channels. Repetitive Electromagnetic Induction (EMI) surveys will be used to observe the wetting and drying of the soil over several consecutive seasons. The results of this work will be applicable to pedotransfer function development and environmental simulation modelling, with relevance to those addressing land management issues such as land owners and local/ regional governance. GPR and EMI results will be presented.

Biological nitrification inhibition activity of New Zealand native and introduced plant species.

Yeganeh Eslami[1], Amanda Matson[1], Lauren Waller[2], Sarah Addison[1], Steve Wakelin[2,3]
[1]Scion, Rotorua, New Zealand, [2]Bioprotection Research Centre, Lincoln, New Zealand, [3]Scion, Christchurch, New Zealand

There is an urgent need to reduce the impact of high levels of added nitrogen used to grow food and fibre on New Zealand ecosystems. The impacts of elevated soil nitrogen on water quality and greenhouse gas emissions are clearly established. In many regions nutrient caps are being imposed to limit the movement of nitrogen and other nutrients into sensitive catchments.

Work overseas has identified a range of plant species naturally adapted to grow in low nitrogen soils. This is often associated with a trait called 'biological nitrification inhibition' (BNI), which allows plants to reduce the rate of nitrogen cycling in soil adjacent to their root systems. BNI occurs through root-secreted chemical inhibition of specific soil microorganisms. However, the effect can be very specific, varying in strength among species.

We screened a phylogenetically diverse range of plant species, both endemic to New Zealand and exotic for potential BNI activity, by growing 39 plant species from 14 families in a common soil system and measuring the rate of oxidation of ammonia to nitrate from the root zones (surrogate for BNI). DNA analysis of the soil was used to quantify populations of the target BNI microorganisms; ammonia oxidising bacteria (AOB) and archaea (AOA).

When compared to a reference plant (Lolium perenne) BNI varied significantly across plant species. No strong relationships were found between BNI and introduced or endemic plant species indicating the trait may not be related to invasiveness. Furthermore, BNI activity was not linked with broad phylogenetic groups, but rather varied on a species-by-species basis. Strong BNI was measured in some NZ endemic species raising the potential to use these for management of N-cycling in different ecosystems. BNI wasn't linked with total abundances of AOB nor AOA, suggesting future molecular work targets microbial activity (mRNA expression) rather than total taxa counts.

Elaborate differences between trees and understory plants in the deployment of fine roots

Peipei Jiang[1], Huimin Wang[1], **Dr Xiaoli Fu**[1], Xiaoqin Dai[1], Liang Kou[1]
[1]Institute Of Geographic Sciences And Natural Resources Research, CAS, Beijing, China

Spatially segregating root systems is a fundamental mechanism by which plants can avoid competition for resources. Understory roots contribute substantially to total forest fine-root biomass, but the strategy of function-based fine root placement between trees and understory species at the plant community level is unknown. We collected fine roots of trees and understory species in two subtropical coniferous forests, sorted the fine roots into absorptive and transport roots, determined the vertical placement of these two types of fine roots, and examined the abiotic and biotic factors that may regulate the horizontal allocation of fine roots. We found that the contribution of absorptive shrub roots to absorptive roots of the woody plants was higher than the contribution of total shrub fine roots to the total fine roots of the woody plants in the topsoil. Understory plants allocated a greater proportion of their absorptive roots to transport roots (RatioA/T) and more total fine-root biomass than trees in the topsoil. Trees had a lower RatioA/T in the topsoil; but increased their contribution of fine-root biomass to the total fine-root biomass and RatioA/T with depth. The proliferation of shrub fine roots in the topsoil was affected more by soil structure (rock-fragment content and bulk density) than by nearby stems, and the growth of tree fine roots was inhibited by nearby dense and/or large stems. Our results provide evidence of an elaborate differentiation of root deployment between trees and understory plants. The roots of understory plants dominated the topsoil by possessing a higher branching capacity of absorptive roots than trees, filling the readily occupied macropores and being less affected by nearby stems. Trees enhance their resource foraging towards deeper soil by increasing their advantage of occupying soil volume and branching capacity of absorptive roots with depth.

Water use efficiency of vegetable crops in the United Arab Emirates

Steve Green[1], Mansoor Al Tamimi[2], Ali Al Sharouf[3], Wasel Abou Dahr[2], Steve Dixon[4], Brent Clothier[1], Mohammed Dawoud[2]
[1]Plant & Food Research, Palmerston North, New Zealand, [2]Environment Agency Abu Dhabi (EAD), Abu Dhabi, United Arab Emirates, [3]Abu Dhabi Food Control Authority (ADFCA), Al Salamat, United Arab Emirates, [4]Maven Consulting, Wellington, New Zealand

Many Farmers in the United Arab Emirates (UAE) are uncertain about the water requirements of field crop in this water-short, hyper-arid region. Excess irrigation is needed to avoid salt accumulation in the root zone. However, over-watering of the crops also threatens the sustainability of the groundwater resources. The Government of Abu Dhabi has recently passed Law 5 to restrict groundwater use. Farmers must improve their irrigation practices by better matching irrigation supply to crop water demand.
This paper presents results from a field experiment to determine the water requirements of the five main field crops (tomatoes, cucumbers, cabbages, egg plants, and capsicums) which are drip irrigated using sweet water (1 dS/m) spiked with a daily dose of macro and micro nutrients. The experiments are being carried out at Abu Dhabi Food Control Authority (ADFCA) research farm, near Al Ain. Crop water use is measured using weighing lysimeters (72 L pots), soil water contents are measured using TDR (time domain reflectometry), irrigation volumes are measured using flow meters, and drainage losses are recorded using tipping-spoon devices. Drainage water is analysed once a week to assess nutrient losses. Local weather data are used to calculate the hourly and daily potential evaporation rate (ETO), and thereby derive an appropriate value for the crop factor, KC, that relates crop water use to the prevailing microclimate. Final crop yields have been recorded at a commercial time for harvest (12-14 weeks after planting), in order to quantify the water-use efficiency (kg crop per L of water). Information from our field experiments are being used to parameterize a decision support tool for Irrigation Allocation that is being developed for Environment Agency - Abu Dhabi (EAD) to better manage the groundwater usage in a sustainable way.

Soil and microclimate impact predicted and actual permanent pasture productivity

Dr Belinda Hackney[1,2], Dr Susan Orgill[1,2]
[1]NSW Department Of Primary Industries, Wagga Wagga, Australia, [2]Graham Centre for Agricultural Innovation, Wagga Wagga, Australia

Topography and aspect influence soil properties, and combinations of these soil-forming factors are typical of pasture fields in the high rainfall zone (>650mm AAR) of south-eastern Australia. Despite this, position in the landscape is rarely considered when making decisions regarding fertiliser and amendment inputs to these pastures. Three-year pasture production experiments were established in upper and lower slope locations on northern and southern aspects of two topographically diverse native grass fields; Central Tablelands (Site 1) and Monaro region (Site 2) of NSW. Soil temperature and accumulated growing degree days were higher on the northern vs southern aspects. Across both sites soil moisture was more favourable for sustaining pasture growth on the southern aspect, with some significant ($P<0.05$) differences detected between upper and lower slope locations on northern aspects. Pasture growth indices for Site 1 were strongly influenced by differences in soil temperature between the northern and southern aspects with greater pasture growth predicted on the northern aspect. However, actual pasture growth over the three-year study was 30-40% lower on the northern vs south aspect, with the magnitude dependant on slope position. Despite more favourable soil temperature on the northern aspect, our data suggest that the lower density of productive perennial species on the northern vs southern aspect was likely due to erratic soil moisture conditions. Conversely, at Site 2 differences in overall growth index were predominantly influenced by available soil moisture with higher production predicted on the southern vs northern aspect. Actual herbage production over the three-year study was 20% higher on the southern vs northern aspect at Site 2. The results of this study indicate greater appreciation of climatic and soil moisture conditions in variable landscapes is required to better rationalise decisions regarding fertiliser rates and application, as well as grazing management to ensure optimal use of farm resources.

Reducing nitrate leaching risk from a pasture soil by increasing dairy cow urine patch size

James Hanly[1], Stefanía Romero-Ramírez[1]
[1]Massey University, Palmerston North

The cow urine patch is a major source of nitrate (NO_3^-) leaching from grazed dairy pasture farms. Therefore, increasing urine deposition area is expected to directly reduce N leaching losses. However, there has been limited research that has quantified the effectiveness of this mitigation across a range of different soil and climatic conditions. The objective of this study was to determine the effect of increasing the cow urine deposition area on NO_3^- leaching risk and short-term pasture accumulation on a Recent soil in the Manawatu Region, New Zealand. A field trial was conducted using mowed pasture plots that received the following treatments: Urine (1 m2), Urine (0.2 m2) or No-urine. Each treatment was replicated 6 times. The two urine treatments received 2.1 L of real cow urine/patch. Urine treatments were applied in early autumn, and soil inorganic N was measured on three occasions; 15, 36 and 53 days after urine application (DAUA). The third soil sampling time occurred 24 days after it was estimated that drainage had commencement. At this sampling time, the net inorganic N (i.e. minus the No-urine treatment value) in the 45-120 cm soil depth was 63.6% lower for the Urine (1 m2) treatment compared to more typical urine patch area of 0.2 m2. Over the two pasture harvests conducted in the trial, the two urine patch treatments achieved a similar level of pasture DM accumulation to that of the No-urine treatment. The lack of a pasture growth response from the added urine could have been influenced by the high clover content (35.9%) of the pasture and, in addition, there may have been adequate background soil mineral N levels, which together could have contributed to N not being growth limiting during the trial period.

A new suction cup and lysimeter array (SCALAR) system to measure leaching losses

Trevor Hendry, William Talbot[1], Roger Atkinson[1], Nigel Beale[1], H.J. Di[1], Keith Cameron[1]
[1]Centre for Soil and Environmental Research, Lincoln University, Lincoln, New Zealand

Current systems for measuring leaching losses under grazing, or cultivation, each have their own advantages and disadvantages. Limitations of lysimeters include their cost, difficulty of use under grazing or cultivation, and needing to use calculations to scale up results to paddock scale. Suction cups also have limitations, including labour intensive sampling of each individual cup, difficulty of use under cultivation (often requiring removal and re-installation), spatial variability of results under grazing, and need to have a separate measurement (or calculation) of drainage volume.
The aim of this research project was to develop an improved system that uses a suction cup and lysimeter array (SCALAR) system to overcome some of the current limitations to quantify leaching losses in the field.
In the SCALAR system, each suction cup is located at 700mm depth, the top of each suction cup pipe is located at 350mm (i.e. allowing for cultivation), each suction cup is connected via two nylon tubes (at 350mm depth) to a single collection/retrieval site where a vacuum/pressure pump is used to apply 10kPa suction or pressure of 60kPa to transfer the solution sample to a collection manifold. Sixty four suction cups are installed at 5m intervals in a grid pattern covering an area 35m by 35m. A tipping bucket rain gauge and six lysimeters at the edge of the paddock automatically measure water input and drainage (using tipping bucket devices) and the data captured on a data-logger.
The advantages of the new SCALAR system include: being less labour intensive (post-installation); the ability to measure leaching under cultivation and under grazing; not needing to use a calculation to scale up the results; and having measurements of soil solution concentration and drainage.

Changes in drained peatland extent for the Lake Poukawa catchment, Hawke's Bay

Reece Hill[1], Dan Borman[1], Peter Singleton[2], Barry Lynch[3]
[1]Landsystems Limited, Hamilton, New Zealand, [2]Natural Knowledge, Hamilton, New Zealand, [3]Hawke's Bay Regional Council, Napier, New Zealand

Drainage of peatland and conversion to agricultural land use leads to on-going peat subsidence from peat oxidation and densification. The rate of loss and changes to the mapped extent of peatland area are important considerations for farm systems planning and soil management.
The wetland areas immediately surrounding Lake Poukawa were first drained in 1928. Before drainage the area was predominantly wetland including flax harvesting. Following drainage, land use has changed to a mix of pastoral use and cropping.
As part of a regional peatland survey, our study aimed to map the extent and depth of the contemporary Lake Poukawa peatland area and use newly collected and historic data estimate peat subsidence rates since drainage.
Hawke's Bay Regional Council predecessors collated land surface and peat depth records on the peatlands from the 1930s through to the 1980s. Additionally, a previous national peatland survey (circa. 1978) provided nine peat depth sample records and a peat depth contour map. All records were only available in hard copy reports with limited ability to accurately locate the sample sites and estimate peat depth.
In our survey more than 100 peat depths were measured using peat depth rods and soil auger observations. Historic sample site locations were remeasured where feasible, following relocation using GIS techniques. A combination of approaches compared the historic and new data to estimate the changes in peat depth and delineate a contemporary map of peatland extent and peat depth for the Lake Poukawa catchment. The new measurements of peatland extent and depths provide evidence of subsidence and peatland edge shrinkage (including the loss of areas of Organic Soils - now likely classified as Gley Soils). The data indicated peatland subsidence rates of 20 to 30 mm/year, in line with national and international data for peatland subsidence rates following drainage.

A comparison of four methods for assessing treading damage

Jay Howes[1], James Hanly[1], Dave Horne[1], Mike Hedley[1]
[1]*Massey University, Palmerston North, New Zealand*

Treading damage inflicted by grazing animals degrades soil physical quality, increases sediment and nutrient loss to water, and reduces pasture utilisation and yield. The extent or severity of treading damage can be assessed using a number of methods including; roller chain, depth of pug, visual scoring. However, the ability of these methods to assess treading damage, and their relative merits, has not previously been compared. Four methods of measuring treading damage are compared in this study including the three methods mentioned and a new tool called the pugometer, which was developed to measure treading damage in a spatially explicit manner. These comparisons were conducted on three paddocks at Massey University's Dairy 4 farm near Palmerston North, Manawatu, New Zealand. These paddocks had sustained treading damage of varying levels during grazing in wet conditions. Treading damage inside a quadrat (0.6 m x 1.0 m) was assessed at 25 sites in each paddock using the four methods.
All four methods were able to identify varying degrees of treading damage with strong correlations between them (R2 = 0.72 to 0.87). Therefore, the selection of the most appropriate method to assess treading damage will depend on the circumstances. The visual scoring method was the quickest and simplest method to perform over a large area, and so could be employed easily by a farmer. In contrast, while the pugometer took twice as long to measure treading damage on the same area, it provided a quantitative measure of the spatial variability of treading damage and so would be a useful research tool. The depth of pug and roller chain methods are reliable but much more time consuming and therefore are only practicable as research tools for small plot studies.

Mineral N stock and nitrate accumulation in deep profile on the Loess Plateau

Dr Xiaoxu Jia[1]
[1]*Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China*

Nitrogen (N) stored in deep profiles is important in assessing regional and/or global N stocks and nitrate leaching risk to groundwater. The Chinese Loess Plateau, which is characterized by significantly thick loess deposits, potentially stores immense stocks of mineral N, posing future threats to groundwater quality. In order to determine the vertical distributions of nitrate and ammonium content in the region, as well as to characterize the potential accumulation of nitrate in the deep loess profile, we study loess samples collected at five sites (Yangling, Changwu, Fuxian, An'sai and Shenmu) through a 50 to 200 m loess profile. The estimated storage of mineral N varied significantly among the five sites, ranging from 0.46 to 2.43 × 104 kg N ha-1. Ammonium exhibited fluctuations and dominated mineral N stocks within the whole profile at the sites, except for the upper 20-30 m at Yangling and Changwu. Measured nitrate content in the entire profile at Fuxian, An'sai and Shenmu is low, but significant accumulations were observed to 30-50 m depth at the other two sites. Analysis of δ15N and δ18O of nitrate indicates different causes for accumulated nitrate at these two sites. Mineralization and nitrification of manure and organic N respectively contribute nitrate to the 0-12 and 12-30 m profile at Changwu; while nitrification of NH4+ fertilizer, NO3- fertilizer and nitrification of organic N control the nitrate distribution in the 0-3, 3-7 and 7-10 m layer at Yangling, respectively. Furthermore, our analysis illustrates the low denitrification potential in the lower part of the vadose zone. The accumulated nitrate introduced by human activities is thus mainly distributed in the upper vadose zone (above 30 m), indicating, currently, a low nitrate leaching risk to groundwater due to a high storage capacity of the thick vadose zone in the region.

Pasture production response to zeolite incorporation in a pumice soil

Amanda Judge[1], Dr Brendon Welten[1], Dr Mark Shepherd[1], Alec McGowan[1]
[1]AgResearch, Ruakura Research Centre, Hamilton, New Zealand

Zeolite is a natural mineral that is known to readily exchange a wide range of cations and have a high water holding capacity. These properties of zeolite have the potential to increase pasture production by improving soil nutrient and water retention, particularly in free-draining pumice soils, which have low cation exchange and water holding capacity. A preliminary assessment of a pasture production response from incorporating zeolite into a developing pumice soil was undertaken in a field mowing plot study located in the central north island, NZ. The plot study was established with five zeolite application rates (ranging from 0 to 100 ton ha-1) by two contrasting soil fertility levels (designated moderate and high) with pasture production and soil measurements carried out over a 413-day study period. Preliminary results showed that zeolite had no effect on pasture growth at the high soil fertility level but did show a trend for an asymptotic pasture production response with the rate of zeolite applied at the moderate soil fertility level. This study highlights that soil fertility status plays an important role in a pasture production response to incorporating zeolite in pumice soils.

Formulating Technosols to Reduce Salinity and Water Stress of Crops Growing under Aridic Conditions

Chao Kong[1], Marta Camps-Arbestain[1], Qinhua Shen[1], Brent Clothier[2], Felipe Macías Vázquez[3]
[1]School of Agriculture and Environment, Massey University, Palmerston North, New Zealand, [2]Plant & Food Research, Palmerston North, New Zealand, [3]Facultad de Biología, Departamento of Edafología y Química Agrícola, Universidad de Santiago de Compostela, Santiago de Compostela, España

Salinity and drought stress are two severe threats to agriculture especially in arid and semi-arid regions. Increased soil degradation of arable land due to salinization is expected to result in around 30% of land loss within the next 25 years, and up to 50% by the year 2050[1]. This will decrease our ability to meet food security for a growing world population. Therefore, exploiting specific restoration techniques for alleviating salt and drought stress should be given high research priority. For this, we propose the formulation of tailor-made Technosols and study their effectivity in reducing salt stress, in conditions simulating the Halib Sakia El Hamra region in Western Sahara under intensive agriculture. The main ingredients from which the Technosols will tentatively include: sand (to minimize the capillary rise of salty water), either biochar or pumiceous material (to act as nuclei for salt precipitation), algae compost (as a source of organic matter), micro-silica (to provide the crop with a greater tolerance to drought stress, and pest-resistance), and diatomaceous earths (to entrap salts and rendering them unavailable for plant uptake). Different combinations and ratios of these ingredients will be tested so that the crop yield is optimized. In the next months, we will study the effect of the combinations of sand with either biochar or pumiceous material on alleviating the salinity induced with saline irrigation water, and the preliminary results will be presented at the conference.

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Biological nitrification inhibition in forage crop rhizosphere soils

Andrea Leptin[1], Dr David Whitehead[2], Prof. Keith C. Cameron[1], Dr Niklas J. Lehto[1]
[1]Department of Soil and Physical Sciences, Lincoln University, Lincoln, New Zealand, [2]Manaaki Whenua - Landcare Research, Lincoln, New Zealand

The conversion of dryland sites into irrigated grassland for dairy farming has led to an increased risk of nitrogen (N) losses. This important nutrient is lost through leaching (mainly as nitrate) and as gaseous emissions of nitrous oxide (an important greenhouse gas).

During nitrification, relatively immobile ammonium is oxidised to highly mobile nitrate, which can leach easily or undergo conversion to gaseous nitrous oxide via denitrification processes, thus, may lead to N being lost from the soil. A measure to reduce N losses resulting from nitrification is the utilisation of biological nitrification inhibitors (BNI) released as exudates by roots of certain plant species. Several plant species have been shown to influence nitrification in the soil. However, the size of this effect as well as the underlying mechanisms have not yet been investigated for common forage crops in New Zealand. This study focuses on the quantification of the differences in BNI activity between common forage crops in New Zealand.

We grew plantain (Plantago lanceolata), chicory (Cichorium intybus), and perennial ryegrass (Lolium perenne) under controlled environmental conditions in a pasture soil that had been exposed to historically high (300 kg urea-N/ha) and low (0 kg urea-N/ha) N loading rates. We used wild radish (Raphanus raphanistrum) as a positive BNI control. After harvesting the plants, we measured the potential nitrification rate (F_NP) as well as the microbial biomass and the abundance of ammonia oxidising archaea and bacteria in the rhizosphere.

We used the differences in F_NP between the plant rhizosphere soils to derive potential BNI capacities for the plant species. The microbial biomass as well as the abundance of nitrifying microorganisms gave us insight into the underlying mechanisms of nitrification inhibition.

Influence of lime, phosphate and fluoride applications on the water extractable-organic carbon of Allophanic soil

Yang Li[1], Marta Camps-Arbestain[1], Qinhua Shen[1], Tao Wang[2], Catherine Whitby[3]
[1]School of Agriculture and Environment, Massey University, Palmerston North , New Zealand, [2]Department of Biology, Microbial Ecology Group, Lund University, Lund, Sweden, [3]Institute of Fundamental Sciences, Massey University, , New Zealand

The influence of lime and phosphate fertiliser application on the stability of soil organic carbon (SOC) has been extensively studied. However the effect of these amendments on the stability of organo-mineral interactions, remains uncertain. When organo-mineral complexes are destabilised, the chemical protection provided by the minerals to the organic ligands is impaired, and can lead to the release of organic carbon that is water-extractable (referred to as WEOC). The aim of this study was to investigate the changes in WEOC in an Allophanic soil from the Taranaki region (New Zealand) caused by the additions of different rates of lime, phosphate (PO43-) and fluoride (F-), and combined treatments of lime and PO43-, as well as lime and F-. A significant increase in WEOC (491.2 to 768.2 mg/kg) ($P<0.05$), along with a decreased organic carbon/organic nitrogen ratio and an increased aromatic C content in the WEOC fraction, were observed as soil pH was increased from 5.2 to 6.5 by addition of lime (2, 4, 6 and 8 g/kg). Similar trends were induced by addition of phosphate (100, 200, 300 and 400 mg/kg) and fluoride (50, 100, 200 and 400 mg/kg). The combined effects of PO43- and lime, or that of F- and lime on WEOC were stronger than that of PO43-, F- and lime addition alone. These results provide direct evidence that lime and phosphate fertiliser applications could increase the aqueous solubility of SOC, particularly the combined application of lime and phosphate fertiliser. This could be attributed not only to ligand competition (OH-, PO4, F-), but also to the weakening of H-bonds at increasing pH values. Further studies on the effects of lime, phosphate and fluoride additions on the chemical composition of WEOC will be conducted to achieve mechanistic understanding of the response of SOC dynamics to these agricultural practices.

Estimating phosphorus losses in surface runoff and subsurface flow from soils receiving dairy factory wastewater

C Lizarralde[1], RW McDowell[2], LM Condron[1], J Brown[3], J Russell[3]

[1]Lincoln University, Lincoln, New Zealand, [2]AgResearch Limited, Lincoln, New Zealand, [3]Fonterra Limited, Palmerston North, New Zealand

Large amounts of phosphorus (P) enriched wastewater are generated during the processing of milk and dairy products. In New Zealand, land treatment, involving irrigation on to farms, is the preferred method. Long-term application of wastewater is likely to result in the accumulation of significant quantities of P in the soil, which in turn increases the risk of P transfer to waterways. However, it is thought that the addition of Ca in the wastewater may increase soil pH and decrease the potential for P loss to surface runoff and subsurface flow – approximated by soil water soluble P (WSP) and CaCl2-P, respectively. The aim of this study was to assess if WSP and CaCl2-P in neutral to alkaline soils receiving wastewater can be estimated applying a published relationship, using Olsen P, Anion Storage Capacity (ASC), to estimate WSP and CaCl2-P for slightly acidic agricultural soils. Over 450 topsoil samples were collected from land adjacent to eight dairy factories and analysed for P analysis. The mean concentrations were 41% (10-92%) ASC, 154 mg/L (4-691 mg/L) Olsen P, 0.44 mg/L (0.01-2.12 mg/L) WSP and 1.6 mg/L (0.001-13 mg/L) CaCl_P. Concentrations of WSP and CaCl2-P estimated using the relationship established between Olsen P and ASC in New Zealand grassland soils were well correlated (r = 0.82 and 0.78 for WSP and CaCl2-P, respectively) to those measured. However, depending on the soil and the length of time it had been irrigated, estimates were also lower than those measured, and the relationship to those measured was, at times, curvilinear. This data shows that constituents in wastewater, potentially unrelated to Ca, have boosted WSP and CaCl2-P beyond those estimated. Therefore, field measurements of P loss in surface runoff and subsurface flow are required to recalibrate the published relationship for estimating P loss in soils irrigated with wastewater.

Earthworm abundance influences soil ecosystem services provision

Trish Fraser[2], **Alec Mackay**[3], Nicole Schon[1]

[1]AgResearch Limited, Christchurch, New Zealand, [2]Plant & Food Research, Christchurch, New Zealand, [3]AgResearch Limited, Palmerstron North, New Zealand

Earthworms contribute to a range of soil services and have been suggested as useful indicators of soil health and soil quality. It is important to understand the abundance levels at which earthworms must be present in soil before benefits of their services become apparent. Hence the aim of this study was to explore the interaction between earthworm abundance and the provision of soil ecosystem services in a pastoral system. Mesocosms were established in 20L buckets, containing a Pallic soil sown with Italian ryegrass (Lolium perenne). Treatments were replicated four times and included the addition of no, low (110/m2), medium (225/m2) and high abundance of earthworms (570/m2). Each mesocosm contained either a functionally diverse earthworm community, including Lumbricus rubellus, Aporrectodea caliginosa and Aporrectodea longa at a ratio of 2:6:2, or a single species, of either A. caliginosa or A. longa.

Both earthworm species and abundance influenced the provision of soil services. Only the highest abundance of earthworms increased pasture growth. As earthworm abundance increased (especially A. longa), surface water infiltration rates and soil macroporosity also increased, although the influence on drainage was variable. Total soil nitrogen increased with increasing earthworm abundance, with a concomitant reduction in the soil C:N ratio.

Management practices which increase earthworm abundance will benefit the provision of soil services. This study suggests that increasing earthworm abundance over 225 earthworms per square metre, potentially up to 570 earthworms per square metre is necessary for these benefits to become evident.

Impact of manipulating dietary crude protein intake on partially housed dairy cows on NH3 emissions

Miss Khadija Malik[1], Mr Nouman Kyamanywa[2], Dr Peter Bishop[1], Dr Mike Hedley[1], Dr Surinder Saggar[3]
[1]Massey University , Palmerston North, New Zealand, [2]Ravensdown, Fielding, New Zealand, [3]Landcare Research , Palmerston North , New Zealand

Dairy industry intensification in some areas of NZ has led to increased N loss to water. Practicing duration controlled grazing; using temporary housing systems (naturally ventilated barns) can reduce urinary load to paddocks and N loss to water. There is concern that ammonia (NH3) loss to atmosphere during housing, manure storage and re-application to pasture results in pollution swapping i.e. decreasing N loss to water while, increasing the greenhouse gas emission footprint of dairying. In NZ, dairy cows graze in pasture based production systems, however when the pasture becomes limiting during summer then cows are fed supplements like maize and pasture silage. This change in diet also impacts N excretion and milk production. The present study was part of dietary trial which investigated the effect of change of summer diet on crude protein intake and N excretion. The main aim of present study was to investigate the impact of manipulating crude protein levels in feed supplements on excreta NH3 emissions. For this experiment, 54 dairy cows were used split in 3 groups and fed on high crude proteins (25%), medium crude proteins (18.5%) and low crude proteins (13.5%). NH3 emissions from the slurry mixture were measured in vitro in a laboratory set up at room temperature (20 oC) for 6 days. The set up consisted of 11 Agee jars (1 L) with passive acid traps (10 ml 0.5 M H2SO4) contained in 50 ml pink top containers. The cumulative NH3 losses were reported based on the urea N and total Kajeldahl N applied to each Agee jar. The results showed that NH3 emissions reduced by 13.87 – 20.11% with decrease in dietary crude protein from 13.5 to 25%. We concluded that manipulating the CP level in diet can reduce urinary N excretion and hence low NH3 emissions.

Nitrogen movement after urea application to a young Pinus radiata forest on pumice soil

Amanda Matson[1], Loretta Garrett[1], Peter Beets[1], Brian Strahm[2], Tim Clough[3]
[1]Scion, Rotorua, New Zealand, [2]Virginia Polytechnic Institute and State University, , USA, [3]Lincoln University, Lincoln, New Zealand

One third of the planted forest land area of New Zealand is deficient in at least one of the nutrients required for optimal tree growth. This presents a significant impediment to aspirations to double the productivity of New Zealand's planted forests. Fertiliser use could be key in reaching that goal, but knowing when and how to add fertiliser to maximise crop uptake while minimising drainage losses is an ongoing challenge. To better understand the effects of N fertiliser addition on leaching and forest productivity, a trial was established in a young Pinus radiata stand on a low-fertility pumice soil. In the study area, the Pinus radiata Nutrient Balance Model (NuBalM) indicated that 500 kg N ha-1 was required to reach target productivity. Nitrogen applications of 0, 250, and 500 kg ha-1 in the form of urea were applied in a single dose to a replicated block plot design. Harvest residues from the previous tree crop had been windrowed, so sampling was undertaken both between and below the harvest residues. Movement of N was assessed using soil sampling (15N tracer), as well as resin lysimeters and leachate collectors at depth (1 m and 2 m soil depth). Between 20 and 40 mm of leachate was collected at the 1- and 2-m depths in the first 6 months of the study. Fertiliser recovery in the soil was <50% after the first month, though there are strong indications that some of it was retained in the organic layer. This ongoing study highlights the potential for N loss during extreme weather events and has implications for long-term forest management.

Tree willow root growth in sediments varying in texture

Ian McIvor[1], Robert Ward[2], Valerie Desrochers[3]
[1]Plant & Food Research, Palmerston North, New Zealand, [2]Plant & Food Research, Palmerston North, New Zealand, [3]Institut de recherche en biologie végétale, Montreal, Canada

Tree willows are fundamental bioengineering tools for stabilising river banks and confining river flow. Riverbank sediments vary from fine silty clays to coarse gravels or stones.
We investigated the early root development of Salix nigra willow in riverbank sediments.
Cuttings were grown for 10 weeks in layered sediment types in five large planter boxes, each box differing in the proportion of silt, sand and stones. At 10 weeks, the roots were extracted and sorted into diameter classes according to sediment type and depth. Root length and dry mass were measured and root length density (RLD) and root mass density (RMD) calculated.
Root development of S. nigra cuttings varied with the substrate, either silt, sand or stones (gravel). Roots were initiated from the entire length of cuttings in the substrate but with a concentration of initials located at the bottom and close to the bottom of the cuttings. There was substantial root extension into all three substrates and at all depths. Generally, RMD was higher in the stones, influenced by having the bottom of the cuttings located in stones for four of the five treatments. RMD was highest for roots < 1 mm diameter.
Whereas RLD for roots > 0.5 mm diameter was highest in the sand, RLD of roots with diameter < 0.5 mm was lowest in sand. Roots of S. nigra were least effective in binding sand, primarily because of low RLD of roots < 0.5 mm diameter. It is surmised that sand lacks water and nutrients sufficient to sustain growth of fine roots compared with silt and even stones. RLD for roots > 0.5 mm diameter was lowest in silt likely due to the greater resistance of the substrate to root penetration, or possibly the greater investment into smaller roots with absorption capability.

Using remote sensing to quantify soil moisture dynamics in New Zealand's commercial forest estate

Dr Dean Meason[1], Dr Delwyn Moller[2], Priscilla Lad[1]
[1]Scion, Whakarewarewa, Rotorua, New Zealand, [2]Centre for Space Science Technology, Alexandra, New Zealand

The physical properties and depth of soil are crucial factors for soil water movement, storage, and availability for tree uptake in forests. Understanding this information is important for quantifying drivers of productivity in a forest and predicting the potential effects of climate change. However, soils in commercial forests were coarsely surveyed and accurate information of horizon characteristics are very rare. The collection of pedological information through traditional surveying would be very expensive and time consuming. The recent advances in satellite technology has provided the opportunity to collect soil moisture information from forested areas in real time using L Band radar with the European Space Agency's and National Aeronautics and Space Administration (NASA) soil moisture missions. This data could also provide information on the soil physical properties across different forests. However, the data resolution is coarse, and it is unclear it would be able to provide accurate soil moisture data from under a forest canopy on steep and hilly terrain where commercial forests are located. This study analyses data collected by NASA's Soil Moisture Active Passive mission from October 2015 to July 2016 and compares the satellite data to in situ soil moisture measurements taken at two sites in the central North Island and Canterbury. Results to be presented at the conference is on the reliability of the data for different forested areas throughout New Zealand and its accuracy when compared to the in situ soil moisture measurements.

Decreases in soil C and N under irrigation of Pumice Soils

Jamie Millar[1]
[1]*University of Waikato School of Science and Environmental Research Institute, Hamilton, New Zealand*

The use of irrigation has become important for sustaining production of food, fibre and fuel. In New Zealand (NZ), irrigation of pastures is increasing in areas with seasonal water deficits. Nationally, there was an estimated 794,443 ha of land under irrigation in 2017. Mudge et al. (2017) measured a decrease in soil carbon (C) (6.99 t/ha) and nitrogen (N) stocks (0.58 t/ha) to 0.3 m depth in irrigated grazed pastures relative to adjacent non-irrigated pastures. Of their 34 paired sites across NZ, only seven were sampled within the Pumice Soil order. To gain a more comprehensive understanding of irrigation effects on soil C and N stocks in Pumice Soils, I sampled 13 adjacent paired irrigated and non-irrigated sites in the Reporoa Basin, north of Taupo. On average, irrigated pastures had significantly ($P < 0.05$) less soil C stocks (6.8 t/ha) to 0.3 m depth and N stocks (0.36 t/ha) to 0.2 m depth in comparison to adjacent non-irrigated soils. There was no relationship between loss of soil C and N and length of time under irrigation. Presumably loss of soil C and N under irrigation results in release of CO_2 to the atmosphere and potential N leaching into surrounding water bodies. If we are able to determine the causes of these losses, we may be able to identify irrigation approaches that minimise or halt soil C and N losses.

Nitrate and Phosphorous Removal by Novel Couple Bottom Aeration (CBA) Method:Optimization by Response Surface Methodology

Parsa Mohajeri[1], Dr Carol Smith[1], Dr Niklas Lehto[1], Dr Henry Chau[1]
[1]*Department of Soil and Physical Science, Lincoln University, Christchurch, New Zealand*

One of the biggest environmental issues facing New Zealand is N and P contamination of surface water. Nitrogen could be considered as one of the fundamental pollutants in wastewater which could contribute to dissolved oxygen levels, eutrophication effects (excessive richness of nutrients) and toxicity of receiving water bodies. Phosphates enter the water bodies from agricultural fertilizer run-off, discharge of effluents, biological wastes residues while excess of P enters water supply systems, it can cause severe health problems also, such as kidney damage and osteoporosis. The challenge is to find a (sustainable) way to remove the N and P from the wastewater. The main aim of this research is to find a cost effective and sustainable solution for the challenge of remediating wastewater with high N and P content, in terms of innovative materials and an innovative approach to the method of processing wastewater. For processing the wastewater, the new design of the single batch reactor with CBA method in partnership with the different mix designs and characteristics of the adsorbent powder will introduce a new removal system to address environmental wastewater remediation.

The effect of pasture species root traits on water uptake during water deficit

Iván Ordóñez[1,3], Ignacio López[1,3], Peter Kemp[1,3], Daniel Donaghy[1], José Dörner[2,3]
[1]Massey University, Palmerston North, New Zealand, [2]Universidad Austral de Chile , Valdivia, Chile, [3]Centro de Investigación en Suelos Volcánicos , Valdivia, Chile

Soil-plant-water relationships may differ between pasture species for a number of reasons e.g. different root traits. The interaction between these attributes may give mixed pasture swards an advantage over monocultures during water stress periods. The objective of this study was to determine the leaf water relations and soil water dynamics of deep-rooted species, Bromus valdivianus Phil. (Bv) and Plantago lanceolata L. (Pl), and shallow-rooted species, Lolium perenne L. (Lp) growing in Manawatu silt loam. Three replicates of five treatments were grown in 110 m2 plots. The treatments were three monocultures: Bv, Lp and Pl, and two mixtures: Bv+Lp and Bv+Lp+Pl. Soil water content was measured at 10 and 40 cm soil depth. Herbage growth rate, leaf water potential and leaf osmotic potential were determined.

The pastures with Pl (monoculture and mixture) and Bv (monoculture) extracted more water at 40 cm depth than the other pastures (P≤0.05), consuming 30% more water from this depth between 30-11-2017 and 07-04-2017. At 10 cm depth, water uptake was greater for the mixed pastures and Pl (P≤0.05). Leaf water potential measurements indicated that Lp was more stressed than either Bv or Pl. The pasture growth rate for November to December was the same for all treatments, but between December and January, pasture comprising Bv+Lp+Pl grew between 16 and 26 kg ha-1 day-1 more than the other treatments (P≤0.05). It can be concluded that deeper-rooted species Bv and Pl have greater water uptake at 40 cm soil depth in comparison to Lp. This can be related to the lower values of both leaf osmotic potential and leaf water potential of Bv and Pl. Monoculture Lp values suggested more stress, but when it was in the mixture tended to match the values of Bv, possibly indicating a synergistic effect when Lp is grown with these deep-rooted species.

Impact of integrated wheat residue and nutrient management on soil carbon pools and microbial-use efficiency

Bhupinder. Pal Singh[1], Yunying Fang[1]
[1]NSW Department of Primary Industries, Australia, Menangle, Australia

Soil management practices such as crop residue return along with exogenous nutrient inputs (integrated residue-nutrient management) are a topic of great interest, with the aim to improve soil organic matter (SOM), soil structure, microbial growth, and plant nutrients to support crop productivity. However, there are still knowledge gaps on how the interaction of crop residue and supplementary nutrients influence the dynamics of residue-derived carbon (C) in modelling-relevant SOM pools and microbial-use efficiency with implications C storage in soils. We quantified the fate and dynamics of wheat residue-C (δ13C 494‰) in microbial biomass and sequentially-separated soil organic carbon (SOC) pools [i.e., light and heavy C, occluded particulate organic matter (POM) and silt-clay associated SOM)], under integrated residue-nutrient management in two contrasting soils (Luvisol and Vertisol) over eight months. For this study, two levels of wheat residue (6.7 and 20.0 g kg-1 soil) and three input levels (nil, low and high) of each of the nutrients (nitrogen, phosphorus and sulfur), while considering the balanced C-to-nutrient ratios of SOM, were used. The microbial-use efficiency of residue-C at an ecosystem scale (CUEE), was also quantified. The results showed that, under the high-residue input, narrowing of the C-nutrient imbalance decreased the allocation of residue-C in labile C pools (light C fraction and occluded POM), while increasing the incorporation of residue-C into microbial biomass and stable SOC pools (heavy C and silt-clay fractions), in comparison to the no nutrient treatments in each soil. The results suggest a balanced input of nutrients can facilitate utilization of residue-C by microorganisms and incorporation of microbial products/metabolites in the stable SOC fractions. In conclusion, the knowledge acquired in this study on the fate of residue-C in SOC fractions and residue CUEE has the potential to improve predictive performance of models relating to soil functions such as SOM storage in agroecosystems.

Soil nitrification inhibition by urine of sheep fed on plantain (Plantago lanceolata) is cultivar dependent

Trish Fraser[1], Michelle Peterson[1], Denis Curtin[1]
[1]Plant & Food Research, Lincoln, New Zealand

Recent laboratory research has shown that compounds excreted in the urine of sheep fed plantain can cause inhibition of nitrification. Here we show that the extent of inhibition depends on the plantain cultivar that is fed to sheep.

Nitrification was measured in soil microcosms following deposition of urine from sheep fed different cultivars of plantain. Total urine N varied widely between cultivars (1.0 to 4.6 g L^{-1}), with urea comprising between 74 and 95% of the total N. Urines were added to microcosms at a total N concentration of 310 mg kg^{-1} soil and soil nitrate was determined over the course of a 35-day incubation at 20°C. Each of the urines was also treated by solid-phase extraction to isolate the urine organic fraction; the nitrification inhibition ability of this fraction was assessed using a bioassay that uses the Griess assay to track the production of nitrite by pure cultures of ammonia oxidising bacteria in a 100 min incubation.

In the microcosm experiment, there were large cultivar effects on nitrification, particularly in the early phase of the incubation; e.g., nitrate-N produced in the first 21 days ranged from 110 to 235 mg kg^{-1} soil.

Nitrate production in the soil microcosms was inversely related to the degree of inhibition measured in the bioassay.

Our results show that urine composition and the degree of nitrification inhibition by compounds excreted in sheep urine are cultivar-dependent. The results also indicate that the inhibitory activity of plantain urine is associated with its small organic fraction. A bioassay using this fraction may provide a screening tool to identify cultivars that give rise to urine with strong nitrification inhibition potential.

Effect of plantain on the nitrification and abundance of ammonia oxidisers under a urine patch

Andriy Podolyan[1], Hong Di[1], Keith Cameron[1], Cecile de Klein[2]
[1]Centre for Soil and Environmental Research, Lincoln University, Lincoln, New Zealand, [2]AgResearch Ltd, Invermay, New Zealand

Introduction of plantain (Plantago lanceolata L.) as a component of forage pastures has recently been suggested as a farm management practice aimed at reducing nitrogen (N) losses from grazing pasture systems in New Zealand. Research indicates that nitrate leaching and nitrous oxide emissions from grazed pastures containing plantain are lower than from the conventional ryegrass/white clover (RG/WC) pastures. It has been suggested that this could be due to the lower N concentration in the urine of animals grazing plantain, the diuretic effect of the plant leading to a better spread of urine patches, and/or the presence of plant secondary metabolites that inhibit nitrifying bacteria when deposited with urine or as root exudates. However, little is known about the direct contribution of the plantain root exudates compared to the effect of plantain-derived urine on nitrification and microbial communities driving the N-cycle.

We conducted a soil study to quantify the effect of plantain and plantain-derived urine on soil nitrification rates and functional gene abundance of ammonia-oxidising microbial communities in soil under a urine patch. Sixty soil blocks were collected at Ashley Dene Research & Development Station representing pastures with three different plantain contents: 0% - RG/WC only; 30% plantain with the remainder being RG/WC; and 100% plantain. Each pasture type received three different types of urine collected from cows grazing on either 0%, 30% or 100% plantain paddocks. Each type of urine was applied at 0, 450 and 700 kg N/ha equivalent. Soil samples were collected on Day 1, 7, 14, 30, 60 and 90 and analysed for soil ammonium, nitrate and ammonia oxidiser gene abundance.

Here we present some preliminary results of this trial and discuss how changes in the relative abundance of the key nitrification guilds may influence nitrification and N losses from soil.

Development of a mid infrared (MIR) spectral library for estimating properties of New Zealand soils

Dr. Matteo Poggio[1], Dr. Michael Blaschek[1], Dr. Pierre Roudier[1], Eva Totain[2], Dra Carolyn Hedley[1]
[1]Manaaki Whenua - Landcare Research, Palmerston North, New Zealand, [2]SupAgro, Montpellier, France

In recent years, diffuse reflectance spectroscopy has gained much attention from the soils research community as a fast and cost-effective method for soil attribute assessment. Rapid scanning of a soil produces a unique spectrum that can be interpreted to predict soil attributes such as organic carbon, nitrogen, clay content, pH, cation exchange capacity and available water holding capacity. Many studies have focused on the visible-near infrared (VisNIR) range of the electromagnetic spectrum rather than the mid infrared (MIR) range, because VisNIR instruments are more easily deployed and samples require less pre-processing. Nevertheless, MIR spectroscopy has been shown to achieve greater accuracy in soil attribute estimation, with appropriate calibration. Government institutions of countries such as USA and Australia (i.e. USDA and CSIRO) with access to extensive soil datasets have decided to build MIR spectral libraries, and are attaining an accuracy level for predicting several soil attributes that is comparable to standard laboratory analysis.
Manaaki Whenua - Landcare Research possesses an extensive soil archive, of approximately 31,000 air dried and 2-mm sieved samples, with accompanying soil analytical data, dating from 1939. This National Soil Archive includes soil samples with a very wide range of properties collected from all regions of New Zealand. We are scanning these soils and developing calibration models for fundamental soil attributes. This presentation will provide an update on our development of partial least square regression, support vector machine and rule based models (CUBIST) that are being tested and compared to develop calibration models and predict soil attributes from soil spectra. This workstream is part of our proximal soil sensing research that aims to speed acquisition of quality soil data to inform soil mapping and modelling research projects.

Relationship between soil water content and organic matter mineralisation

Dr Weiwen Qiu[1], Dr Denis Curtin[1], Dr Wei Hu[1], Dr Mike Beare[1]
[1]Plant & Food Research, Christchurch, New Zeland

Water controls microbial activity in soils and thus it strongly influences the rate of carbon and nitrogen mineralisation. The aims of this laboratory study were to define the relationship between organic matter mineralisation and water content in soils with different textures, and identify the soil water threshold below which a flush of mineralisation occurs upon re-wetting. Soils collected (0–15 cm depth) from agricultural fields were immediately sieved through a 4 mm sieve. Subsamples were dried to different soil water contents (SWCs) to establish seven treatments spanning the available water range. The SWC-adjusted soils were incubated at 20oC to measure C and N mineralisation (separate incubations for C and N). After four weeks, a subset of samples from each treatment (3 replicates) was wetted to field capacity to identify the SWC at which a mineralisation flush occurs after rewetting. The results showed that mineralisation was linearly related to relative water content (RWC), i.e., soil available water content (i.e., SWC minus wilting point) relative to the total available water capacity (i.e., field capacity minus wilting point). In soils that were at, or above, wilting point, there was no evidence of a mineralisation flush following re-wetting (to field capacity). We concluded that RWC can provide a suitable descriptor for organic matter mineralisation. Soil physical characteristics required to estimate RWC (field capacity and wilting point) are generally available (or can be approximated). Thus, RWC provides a practical index for SWC-adjustment of mineralisation rates.

Plant growth and nitrogen uptake effects on isotopic composition of nitrate leached from pasture systems.

Sephrah Rayner[1], Timothy Clough[1], Troy Baisden[2]
[1]Lincoln University, Lincoln 7647, New Zealand, [2]Waikato University, Hamilton 3216, New Zealand

Worldwide there is increasing awareness of the potential risks that pasture grazing systems pose to freshwater, including faecal contamination and enhanced nutrient loadings. Excess nutrient levels, predominately nitrate (NO_3-), result in a reduction in water quality for recreation, aquifer contamination and reduced drinking water quality, which are costly to mitigate. Attenuation of NO_3- before it reaches freshwater is a potential management tool in these systems. Dual NO_3- isotopes signatures (δ^{15}N-NO_3- and δ^{18}O-NO_3-) can be used to quantify NO_3- attenuation, and apparent isotope fractionation factors to differentiate processes such as denitrification and plant/microbial uptake. However, the role that plant growth and associated N uptake plays in the isotopic composition of the NO_3- from pasture systems is still not fully understood. This study focused on how the presence of plants influenced both the amount of NO_3- leached from a pastural system and its isotopic signature. Using intact soil columns, the effect of the presence or absence of perennial ryegrass (Lolium perenne L.) under varying rates of bovine urine addition was examined. Drainage volumes, dual NO_3- isotopes and leached NO_3- were monitored over a 10-month period. The presence of perennial ryegrass reduced ($P<0.001$) the cumulative leaching of NO_3-, with a leached average of 153.1 kg N ha^{-1} less than those with no plants over the trial period. Bovine urine rate also significantly ($P<0.01$) affected the concentration of NO_3- in drainage. Results for the δ^{15}N-NO_3- and δ^{18}O-NO_3- values were not found to be influenced by plant presence or absence, they were predominantly effected by seasonality, as NO_3- moved through the soil profile. This research is indicative that the effects of plant growth and N uptake do not significantly influence temporal change in NO_3- isotopic signatures and therefore will not confound isotope data used for NO_3- attenuation models within the landscape.

Reducing nitrate discharges from artificial drainage with woodchip bioreactors

Aldrin Rivas[1], Dr. Greg Barkle[2], Brian Moorhead[1], Dr. Juliet Clague[1], Dr. Roland Stenger[1]
[1]Lincoln Agritech Ltd., Hamilton, New Zealand, [2]Aqualinc Research Ltd., Hamilton, New Zealand

Around 40% of dairying land in the country has poorly drained soils that require artificial drainage for their viable use. However, these artificial drains can also provide a pathway for fast and unattenuated nutrient transfers to our streams and rivers. One recent technology that is being widely adopted in the United States to remove nitrate in drainage water are denitrifying bioreactors. These bioreactors are fundamentally a lined pit filled with locally-sourced woodchips as a source of carbon, which microorganisms use to transform nitrate through the process of denitrification into gaseous form of nitrogen, largely N2. We designed and constructed a pilot-scale woodchip bioreactor on a dairy farm on the Hauraki Plains to assess the applicability and performance of woodchip bioreactors under New Zealand conditions as well as to determine any potentially occurring unfavourable side effects. These side effects may include emissions of nitrous oxide and methane (greenhouse gases), hydrogen sulphide ('rotten egg smell') and high concentrations of dissolved organic matter and phosphorus in the bioreactor outflow at start up. Since August 2017, we have monitored flow and temperature continuously and collected samples at the inlet and outlet of the bioreactor for analysis of a suite of parameters including nitrogen, phosphorus and carbon species. Monitoring data during the first drainage season (Aug-Oct 2017) showed that the bioreactor removed more than 99% of nitrate in the drainage water and the negative side effects were mainly apparent only in the early stage of operation. The second monitored drainage season began in May 2018. The results from both seasons will be analysed to identify the factors influencing the performance of the bioreactor in order to optimise the cost and efficiency of future installations in the country.

Effect of the biosolids application method on mānuka essential oil

Salome Seyedalikhani[1], Maria Gutiérrez-Ginés[2], Juergen Esperschuetz[1], Nicholas Dickinson[3], Rainer Hofmann[1], Jason Breitmeyer[1], Brett Robinson[4]

[1]Lincoln University - Faculty of Agriculture and Life Sciences, Department of Soil and Physical Sciences, PO Box 84, Lincoln 7647,, New Zealand, [2]Institute of Environmental Science and Research, PO Box 29181, Christchurch 8540,, New Zealand, [3]Lincoln University - Faculty of Agriculture and Life Sciences, Department of Ecology, PO Box 84, Lincoln 7647,, New Zealand, [4]School of Physical and Chemical Sciences, University of Canterbury, Christchurch 8041,, New Zealand

Countries with sewage treatment facilities produce ca. 52 kg yr-1 of fresh biosolids per person, resulting in the global output of >10 Mt yr-1. Biosolids contain high concentrations of plant nutrients, which have the potential to improve soils fertility. However, they can also contain contaminants such as pathogens, heavy metals, and xenobiotics. Biosolids are widely used on degraded lands for reforestation or cultivation of non-food products. Given the low economic returns from forestry, we sought to determine the effect of contrasting methods of biosolids application on the quantity and quality of essential oils produced by mānuka (Leptospermum Scoparium).

In a 4-month greenhouse experiment, we grew the plants in a Craigieburn silt loam soil (Allophanic Brown Soil). Besides the control treatment (no biosolids added), three rates of Christchurch City Council biosolids of ca. 16, 48 and 145 t ha-1 (0, 630, 1900 and 5700 kg N ha-1 equivalent) were surface-applied or homogeneously mixed into the soil.

Biosolids application at rates equivalent to 630 and 1900 kg N ha-1 provided the greatest biomass increase. Surface application of 1900 kg N ha-1 equiv. of biosolids resulted in the highest oil production (68 kg ha-1). None of the treatments significantly reduced the quality of the oil. Although biosolids increased the concentration of Zn, Cu, and Cd in the plant leaves, the levels were below the ecosystems or human health risk thresholds. In addition to greater oil production, surface application is less expensive and less disruptive to the soil than mixing. On the other hand, surface-applied biosolids are more likely to come into contact with humans or runoff during storms. Field trials are needed to evaluate production economics and ecological variables.

Investigating the Effect of Rising Temperature on Carbon Pools and Fluxes in a Forest Thermo-Sequence in Taranaki

Dr. Qinhua Shen[1], **Idri Siregar**[1], A/Prof. Marta Arbestain[1], Dr. Miko Kirschbaum[2], Dr. Gabor Kerezturi[1]

[1]School of Agriculture and Environment, Massey University-, Manawatu, New Zealand, [2]Landcare Research-, Massey University, Manawatu, New Zealand

Soil organic matter contains more organic carbon (C) than the global vegetation and atmosphere combined, and even small changes in soil organic matter can profoundly affect global C cycling. A better understanding of how soil C stocks and fluxes change in response to increasing temperature is essential for predicting the future soil C feedbacks to global warming. Here, a C balance approach will be used to get a better understanding of potential feedback effects of climate change on soil C stocks and fluxes. The objectives of this study are to (1) evaluate changes in C inputs (litter fall, root, total below ground C flux) and outputs (soil respiration, leaching) to/from the soil, and (2) quantify the net response of soil C stocks to increasing temperature. For this, we will measure soil C stocks and fluxes into and out of organic C-rich volcanic soils across a thermo-sequence with a mean annual temperature (MAT) gradient of 4–5 °C. A transect of five sampling sites across this gradient has been selected at the eastern flanks of Mt. Taranaki volcano, where other factors that can affect ecosystem processes other than temperature are held constant: parent material, moisture, and vegetation. At these sites, soil samples will be taken for total C and its chemical fractions, and soil microbial activity measurements. Soil pore water will be sampled at depth for dissolved organic C measurements. On site, measurements of litter production and soil respiration will be carried out. This information, along with estimates for root-biomass C, will be used for the calculation of total below carbon allocation. We will present some of these results at the conference.

Working with soil natural capital to build better forests

Simeon Smaill[1], Loretta Garrett[2], Peter Beets[2], Dean Meason[2], Peter Clinton[1]
[1]Scion, Christchurch, New Zealand, [2]Scion, Rotorua, New Zealand

The forestry sector has targeted increasing the value of New Zealand's forest exports to $12 billion. Reaching this goal will ultimately rely on effective and sustainable management of the natural capital in soil that supports our planted forests. The "Accelerator Trial" series has been established to implement edge of the envelope forest science to utilise this natural capital in a range of conditions, identifying how to get the most out of soil nutrient dynamics, soil microbial communities and the physical properties of the soil over the life of a rotation. Various treatments are being applied across six large sites to increase soil capitals, such as carbon storage, moisture storage, nutrient storage and biotic properties. The overriding concept is to continuously enhance the ecosystem services flowing from these capitals, sustainably increasing tree growth until incident sunlight is the main limitation. Each site has particular limitations to productivity, which are being addressed initially with specific treatments, including microbial stimulants, manipulation of organic matter storage and alterations to physical soil properties. As one limitation is removed at a site, treatments to address the next dominant limitation will commence. The Accelerator Trial sites have been planted with various pine genotypes, selected to identify those best suited to the physical, chemical and biological capitals at the sites. Various early results have demonstrated the potential to enhance forest productivity by accounting for natural capitals initially at the site, and have also demonstrated the ability to enhance capitals related to ecosystem services mediated by the soil microbial community. These trials are intended to serve as both a long-term source of information for researchers and as demonstration sites for industry. The trial data will improve understanding of how to increase future forest productivity by enhancing both soil natural capitals and ecosystem service provision.

Trichoderma application reduces toxic trace metals in kiwifruit orchard soils and improves overall plant health

Christine H Stark[1], Janaki Kandula[1], Nicholas Cummings[1], Alistair Pullin[2]
[1]Bio-Protection Research Centre, Lincoln, NZ, [2]Agrimm Technologies Ltd, Lincoln, NZ

Disease management in kiwifruit orchards, e.g. against bacterial canker, heavily relies on copper, antibiotics and chemical elicitors. However, concerns have been raised around product efficacy and efficiency, environmental build-up and plant toxicity, resistance development in the pathogen, and international market excess due to residues on fruit. Identifying management strategies that are more environmentally sound is critical to guaranteeing continued sustainable production. Trichoderma are ubiquitous soil-borne fungi that colonise root surfaces and penetrate roots. They are known to be potent biocontrol agents and improve general plant health. They can also enhance plant growth, crop productivity, nutrient uptake and stress resistance and have been identified as potential bioremediators in contaminated soils. We assessed the soil-applied, Trichoderma-based product Kiwivax™ (Agrimm Ltd., Lincoln, NZ) for its potential to improve soil and vine health in kiwifruit orchards by determining its impact on leaf and soil nutrients and total Trichoderma numbers associated with roots. On four kiwifruit orchards in the Bay of Plenty (NZ), areas treated with Kiwivax™ at the recommended dose and frequency were compared with untreated control areas and soil, root and leaf samples were collected repeatedly throughout the trial period (currently 9 months). Preliminary results show that Kiwivax™ application increased Trichoderma counts in roots, SPAD meter readings and levels of selected essential nutrients in planta whereas toxic trace elements were lower in treated compared to untreated soil samples. Kiwivax™ use also resulted in greater yields in two orchards. The observed effects suggest that the soil application of Kiwivax™ in kiwifruit orchards has the potential to improve plant and soil health in the presence of natural disease pressure, and that Trichoderma could play an important role in the reduction of copper levels in the orchard environment. The results warrant more detailed research in kiwifruit orchards as well as other high copper environments.

Effects and subsequent recovery of agricultural land after salt water flooding

Niklas Krüger[1,2], **Matthew Taylor**[1]
[1]Waikato Regional Council, Hamilton, New Zealand, [2]Technische Universität Carolo-Wilhelmina zu Braunschweig, Braunschweig, Germany

A culmination of a king tide, strong to gale force winds, warmer than usual sea temperatures and low barometric pressure resulted in the sea flooding agricultural land around the shoreline of Miranda/Kaiaua on the western side of the Firth of Thames on the 5th January 2018. There were significant impacts to agriculture due to short-term (up to six days) saltwater inundation inducing desiccation and death of crops and pasture. Inundation with salt water also potentially increased the salinity of flooded soils. Although there is a body of literature on the impacts of salt water flooding on soils from studies after tsunami or hurricane events, there appears little if any published studies on the impacts and recovery from smaller events, such as the flooding of the Kaiaua/Miranda coastal area. This presentation reports the effects of salt water inundation from a king tide/storm surge on agricultural soils in a coastal plain and their subsequent recovery. Soils were assessed to ascertain the salinity of the soil in relation to time inundated, how deeply the salt water penetrated into the soil and how quickly the salt washed out of the soil. Elevated salt content was seen most strongly in the top layer (0-2 cm) of the soil and salt concentrations increased with the length of inundation. Salt mediated dispersion of clay blocked soil pores contributing to very poor water infiltration reducing salt incursion deeper into the soil. All maize was killed regardless of the time inundated but ryegrass pasture was killed only after an inundation period of 36 h. Flushing of soil particles with fresh rainwater proved effective at lowering the salt content in the top 2 cm of soil. Salt content was considerably lower after one rainfall event of 35 mm and decreased only slightly more after a cumulative 200 mm of rain. The combined effect of sea level rise and land subsidence may enhance saltwater contamination and soil salinisation with potential serious environmental and socio-economic impacts, e.g. compromising agriculture.

Nutrient management trends observed from repeat Whole Farm Soil Testing results

Hendrik Venter[1]
[1]Analytical Research Laboratories, Napier, New Zealand

Traditionally nutrient management was based upon soil test results obtained from monitor paddocks or blocks representative of different topographies, management and soil types. Greater environmental consciousness and economics contributed to the establishment of Whole Farm Soil Testing to improve soil nutrient monitoring and fertiliser application. Ravensdown has been offering this service since 2011 with the aim to reduce variability between paddocks and driving nutrient levels closer to optimum range limits. A random selection of test results for pH and Olsen P spanning the period 2011 to 2017 were paired with year of first sampling resulting in 6800 sample pairs (Year1:Year 2, …… Year1: Year7). These sample pairs were separated into three scenarios based on whether the first year results were below, within or above the biological optimum level for the particular soil test parameter. Mean values for consecutive years following the first year of sampling, showed that initial below optimum value paddocks trended higher, within optimum range paddocks remained within the optimum range for Olsen P, but increased to within and above the pH optimum range of 5.8 to 6.0. Encouragingly, from both an environmental and economic perspective, a decreasing trend was observed where initial values were above the upper optimum range. It can be concluded that the practice of Whole Farm Soil Testing is a responsible approach to nutrient management with changes in mean soil test values ideally ascribed to improved nutrient application decisions.

Integrating 'biology' into forest soil quality assessments

Mathis Richard[3], Graham Coker[1], Bayne Karen[1], **Garrett Loretta[2],** Smaill Simeon[1], Steven Wakelin[1,4]
[1]Scion, Riccarton, Christchurch, New Zealand, [2]Scion, New Zealand, [3]AroSup Dijon, Dijon , France, [4]Bioprotection Research Centre, Lincoln, New Zealand

Soils sustain many ecosystem services that underpin the productivity and sustainably of planted forest ecosystems. The monitoring of soil health (quality) is important to ensure ecosystem services are maintained, particularly when management systems, climatic conditions, or landuse change are occurring. Furthermore, demonstration of effective soil stewardship may support the forestry sectors' social licence to operate, and ensure access to increasingly environmentally aware markets. Currently soil health monitoring in New Zealand does not formally integrate biological endpoints. This is curious given the integral role of biological diversity and function in supporting soil ecosystem services. We undertook a survey of forest partners (e.g. forest owners, managers, and recreational users etc), to assess their views on the relative importance of a range of forest soil ecosystem services. Overwhelmingly, the ability of soils to provide 'sustainable production over multiple forest rotations' was considered the most important soil ecosystem service. This was followed by 'resilient forest ecosystems', 'high quality water', and 'maximising short term production'. Māori partners placed significantly more emphasis on the importance of 'sustainable forest production' and values associated with provenance and kaitiakitanga (stewardship) than other partners. The results will guide the selection and testing of biological soil health tests targeted for ecosystem services of most importance to forest partners. Furthermore, specific consideration must be given to culturally important values of provenance and kaitiakitanga by Māori interests.

Functional changes in microbial communities linked with low nitrate-N in soils

Steve Wakelin[1], Paul Maclean[2], Vanessa Cave[2], Jizhong Zhou[3], Gwen Grelett[4], David Whitehead[4]
[1]Scion, Christchurch, New Zealand, [2]AgResearch Ltd, Lincoln, New Zealand, [3]University of Oklahoma, Norman, USA, [4]Landcare Research, Lincoln, New Zealand

In agricultural systems, elevated concentrations of soil nitrate (NO3-N) pose an environmental risk associated with eutrophication and greenhouse gas formation. As such, managing soils for low nitrate-N 'phenotypes' – i.e. biogeochemical conditions that support relatively low nitrate-N conditions, is desirable. The aims of this work were to: (1) identify soils with anomalously high or low nitrate N given variation in other soil properties, (2) identify changes in soil N or C-cycling functional genes that may explain differences in nitrate-anomalous soils, and (3) characterise soil physicochemical properties associated with changes in functional genes, and thereby identify opportunities to manage outcomes of ecosystem functions.

The physicochemical and biological components of 50 pasture soils were determined. For the biological characterisation, the environmental microarray 'GeoChip' was used to assess the potential for a wide range of N and C transformations. Soils identified to be relatively low in nitrate-N were compared with the wider sample set were conducted.

Low nitrate-N soils were characterised by having wide ratios of C:P, C:N, and C:S. At a metagenomic level, these soils exhibited increased potential for C-fixation, a greater abundance of genes associated with a wide range of C-compounds, and greater potential for denitrification. Changes in the functional status of the soils was linked to higher abundance of Firmicutes, Actinobacteria, and some Proteobacterial and fungal taxa.

The results show that soils ecosystems can exhibit a phenotype of anomalously low nitrate N, and this is linked to specific physicochemical and biological traits. Managing pastoral soils towards achieving this desirable phenotype maybe achieved through understanding the ecology of the soil ecosystems, and how these respond to management.

Managing forest ecosystems in Mongolia - the crucial role of soil

Anne Wecking[1], Georg Guggenberger[2]
[1]*University of Waikato, Hamilton, New Zealand,* [2]*Institute of Soil Science, Leibniz Universität Hannover, Hannover, Germany*

Forest management in Mongolia has become one of the leading issues with respect to sustainably maintain the country's environmental resources. 7.52% of the Mongolian land area is covered by mountain-taiga and forest-steppe. These ecosystems serve as a significant source to meet the human demand for food and timber. However, sustainable management of this natural resource has been disregarded to great extent in the past and has just recently become acknowledged by international development aid. Since 2009 focus has been drawn on law and lobby enforcement, now being complemented by adaptation strategies to tackle climate change. Primarily drawing attention on above-ground ecosystem functioning; the role of soil, its capability to act as a nutrient reservoir and its overall ability to affect carbon cycling have been neglected. This study reviewed the importance of forest soils in Mongolia at the interface of applied science to international development aid. In order to prove soils to be a crucial factor for forest ecosystem functioning; biological, chemical as well as physical analyses of soil, organic and foliar material were conducted and exemplified for a north facing, 608.41 ha comprising light and dark taiga forest (Tunkhel, Western Khentii Mountains). Findings highlighted forest Phaeozems, Umbrisols, Cambisols and Leptosol to provide considerable preconditions for tree growth. Soil-vegetation interactions were found to be tight, particularly when supported by pyrogenic organic matter incorporation, mycorrhization and freeze-thawing. Pedology corresponded with elevation and microtopography but also included a strong time-related component including sequences of buried Ah-horizons. Results suggested soils to act as a multidimensional regulator in Mongolian forest ecosystems. Overall, findings could evidence the necessity of forest management to consider, to better understand and to further investigate soils as an important driver of forest ecosystem functioning.

Effect of plantain on nitrogen transformations in a free-draining ash soil

Brendon Welten[1], Mike Sprosen[1], Moira Dexter[1], Amanda Judge[1], Stewart Ledgard[1]
[1]*Agresearch, Hamilton, New Zealand*

Plantain (Plantago lanceolata L.) has gained increasing attention as an alternative pasture species to increase the efficiency of nitrogen (N) cycling and decrease N losses by grazing ruminants and thereby reduce farm N losses to the environment. This herb has a fibrous root structure and is known to contain bioactive compounds in plant residues with biological inhibitory properties that could alter soil N transformations. A preliminary laboratory soil incubation and allied acetylene jar incubation study was carried out to investigate the effects of plantain on nitrification of urinary-N and net mineralization rates in a free-draining ash soil. The soil incubation study consisted of soil collected from monocultures of plantain and ryegrass with cow urine applied at two application rates (equivalent to 300 or 600 kg N/ha) and incubated over a 28-day study period for changes in inorganic-N levels. The allied acetylene jar incubation used intact soil cores collected from the same monocultures in the presence of acetylene for 7-days to determine net mineralization rates. Preliminary analyses indicates that soil under plantain delayed nitrification of urinary-N relative to ryegrass soil and was also associated with lower net mineralization rates. This study highlights the potential of plantain to manipulate soil N transformations in a free-draining ash soil to improve N efficiency and decrease N leaching losses.

Repeated application of biosolids improved soil fertility, pine growth and carbon sequestration on marginal land

Jianming Xue[1], Mark Kimberley[2]
[1]Scion, Christchurch, New Zealand, [2]Scion, Rotorua, New Zealand

The objective of this study was to investigate the effects of long-term biosolids application on soil fertility, tree nutrition and growth of radiata pine, and total carbon storage in forest biomass and soil of a marginal site. A research trial was established in a radiata pine plantation forest growing on a Sandy Raw Soil at Rabbit Island in Nelson in 1996. Biosolids were applied to the trial site every three years from 1997 to 2012 at three application rates: 0 (Control), 300 (Standard) and 600 (High) kg N ha-1. Tree nutrition status and growth were monitored annually, and soil properties every three years. Both the Standard and High biosolids treatments significantly increased soil total C, N and P, Olsen P and CEC, and reduced soil pH at the depths of 0-25 cm and 25-50 cm, and increased soil total N at 50-75 cm. Biosolids application significantly increased foliar N concentration and tree stem volume growth since 1998. Compared to the Control, total carbon storage in the stand at age 24 years was increased by 25% and 28% for the Standard and High rates, respectively. Our results indicate that long-term application of biosolids could significantly improve soil fertility and pine productivity on a marginal site, with increased carbon storage in the radiata pine stand and the soil. This study suggests that beneficial use of biosolids on marginal land was an effective means of increasing carbon sequestration in the pine forest and sandy soil.

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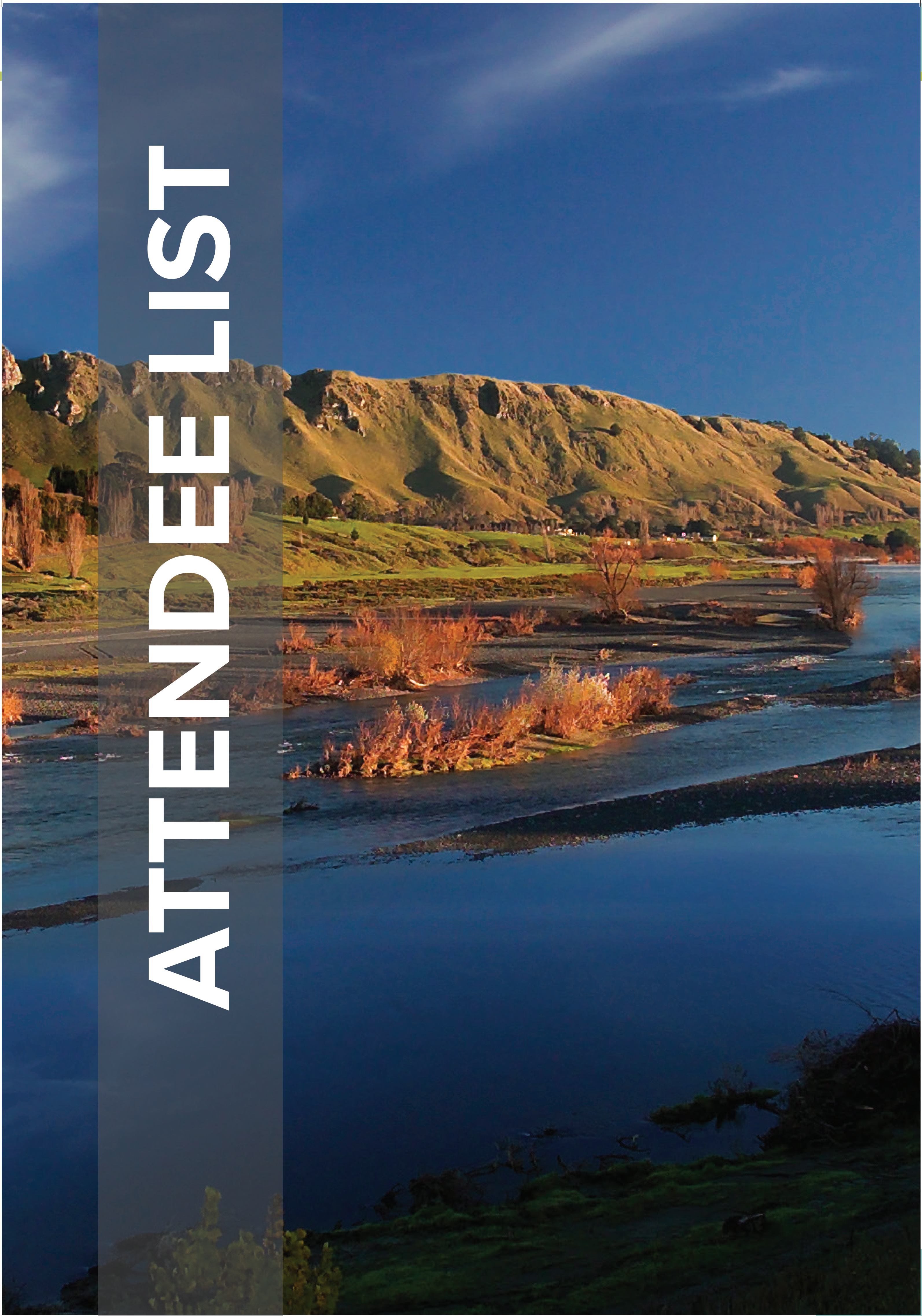

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Sheree	Balvert	Ballance Agri-Nutrients
Mike	Beare	Plant & Food Research
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Estelle	Dominati	AgResearch
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Lisa	Pearson	Land and Water Science
Veronica	Penny	Manaaki Whenua - Landcare Research
Michelle	Peterson	Plant & Food Research
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Ana	Podolyan	Manaaki Whenua – Landcare Research
Matteo	Poggio	Manaaki Whenua - Landcare Research
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