Welcome to the Soil News

February 2019
Issue # 1 -Vol #67

In this issue…

Phosphorus at 350

Your contributions are required - New Zealand Soil News is your newsletter

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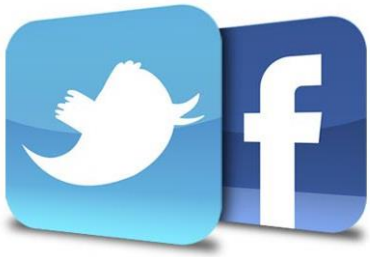

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Editorial

Phosphorus at 350 – the brilliant, essential, and sinister 13th element

2019 marks the 350th anniversary ("sesquarcentennial") of the discovery of phosphorus by Henning Brand. The Soil Science Society of America is marking this anniversary with the publication of a Special Issue of the Journal of Environmental Quality.This has been preceded by an excellent review-commentary written by Andrew Sharpley, Helen Jarvie, Don Flaten, and Peter Kleinman entitled "Celebrating the 350th Anniversary of Phosphorus Discovery: a conundrum of deficiency and excess" [Journal of Environmental Quality 47: 774-777 (2018) doi:10.2134/jeq2018.05. 0170].

This inspired me to organise a series of seminars to highlight contemporary phosphorus research.

This venture has been facilitated by the fact that we currently have 9 PhD projects in the soil science department at Lincoln University devoted to investigating various aspects of phosphorus dynamics in soil-plant systems and sediment.

The presenters will describe ongoing research on chemical, biological and physical properties and processes responsible for determining the dynamics, bioavailability and mobility of phosphorus in soils and sediments at various scales, together with the role and function of phosphorus in livestock production.

Leo Condron: Phosphorus biogeochemistry of New Zealand forest chronosequences.
Xioadong Chen: Impact of long-term nitrogen and manure inputs on alkaline phosphatase activity and bacterial phoD genes in soil.
Zach Simpson: Why do in-stream processes matter for mitigating on-land phosphorus pollution?
Alister Metherell: Remote sensing to predict phosphorus soil fertility and improve fertiliser and environmental outcomes.
Meryem Dreif: Direct application of phosphate rock under different soil conditions.

Nik Lehto: Plastic fantastic: overcoming phosphorus deficiency in heterogeneous soils.
Driss Touhami: Nitrogen and phosphorus limitations and their impact on phosphorus dynamics and bioavailability in the rhizosphere.
Jim Gibbs: Phosphorus in novel forages: how the soil-plant Interaction affects livestock management In New Zealand.
Nadeesha Jayasinghe: Harvesting 100 years of phosphorus studies in livestock: when less works as well as more!
Moussa Bouray: Is soil pH the driver of P availability in high country?
Richard McDowell: Perspectives on global phosphorus flows.
Mohammed Bayed: Remote sensing to map soil water repellency and predict its effect on phosphorus mobility.
Carolina Lizarralde: Risk of phosphorus loss from soil receiving wastewater.
Phuong Nguyen: Mobilisation of legacy soil phosphorus by different plants.
Rosalind Dodd: Phosphorus sinks to phosphorus sources: the impact of legacy P and conservation practices.

Leo M Condron
Professor of Biogeochemistry
Lincoln University

Council Member profiles

This year we have a new president and a quite a few new faces on the NZSSS council. Who are they?

President – Megan Balks

Email Megan - megan.balks@earthbrooke.co.nz

Dr Megan Balks was brought up on a Wairarapa hill country sheep farm. She developed a passion for soil science at Massey University where she completed a BSc(Hons). Megan then worked, for DSIR Soil Bureau in Dunedin as a soil scientist, undertaking soil mapping for irrigation developments in Central Otago. Megan completed her PhD on the effects of meat works effluent irrigation on soil physical properties in the 1990s while working as an assistant lecturer at the University of Waikato.

Megan taught soil and environmental sciences at the University of Waikato for 30 years, particularly focussing on large first year classes. She has supervised over 50 successfully completed graduate theses, on a wide range of soil-related topics, many in collaboration with CRIs and Regional Councils. She now holds an Adjunct Senior Research Fellow position at the University of Waikato and is self-employed, working on writing, and various business interests. She is also currently serving as

the South West Pacific Representative on the "Intergovernmental Technical Panel for Soils" (ITPS) which is run under the Global Soil Partnership by the Food and Agriculture Organisation of the United Nations. Megan is also Vice-chair of IUSS Commission 1.3, Soil Genesis.

Megan has had a long involvement in Antarctic Soil Research, having had 19 field trips to "the ice" since 1990. First undertaking her Antarctic "apprenticeship" with Graeme Claridge and Iain Campbell, she has since had a long Antarctic research collaboration with Landcare Research and the USDA.

Megan served two terms as Chairperson of the Department of Earth and Ocean Sciences at the University of Waikato, two terms on the Waikato Conservation Board (including one as Chair), and two terms as a Director of the QEII National Trust. She is an Honorary life member of the Hamilton Junior Naturalists Club. Megan is married to Errol Balks, a land surveyor, and has one adult son. Megan and Errol own a small hill country sheep farm on the lower slopes of Mt Pirongia which includes over 20 ha of QEII covenanted lowland forest. Other interests include wool crafts, landscape art and photography, gardening, NZ flora, fauna, and geology.

Megan is a Fellow of the New Zealand Society of Soil Science, and was honoured as the NZSSS Norm Taylor Memorial lecturer in 2008 (the first women to achieve either of those awards). Megan returned to the NZSSS Council after a break of 15 years (having formerly served on Council from 1991-7). Megan hopes to contribute her skills and energy to helping the NZSSS ensure the strength of New Zealand soil science and to promote the widest possible understanding and appreciation of the importance, and intrinsic interest and beauty, of our soil resource.

Tim Clough

I completed a BAgSci (Hons) in soil science at Lincoln College. I started work at MAF's Ruakura campus and was lucky enough to undertake my PhD while on staff there with Stewart Ledgard, through Lincoln University, while playing squash, touch rugby and multi-sporting. I returned to Lincoln University as a Marsden Fellow in 1997, with Rob Sherlock and Keith Cameron, to examine the 'Enigma of ^{15}N balances', and went on to receive fellowships to study N cycling processes, first with Jim Stevens in Belfast, 1998, and then using a Fulbright Senior Scholarship with Dennis Rolston, 2000, at UC Davis. I have a wide range of soil interests focusing on understanding C and N cycling, especially though the use of stable isotope techniques. In addition to teaching, supervising post graduate students, and research, I also undertake roles as the Senior Editor for New Zealand Journal of Agriculture, and as a Chief Editor for Soil Biology & Biochemistry.

Dave Houlbrooke

Dave Houlbrooke comes from an agriculture background having been brought up on family sheep and beef farms in the Wairarapa and the Waikato. He studied the discipline of soil science through the completion of a B.Sc (1994) and M.Sc Hons (1996) in Earth Sciences at the University of Waikato. Following a period of employment by Western Australian Dept. of Agriculture he undertook a soil science PhD (2005) at Massey University investigating the improved management for the land application of farm dairy effluent and the impact of intensive dairy farming on nutrient loss through artificial drainage systems.

Dave has been a soil scientist with AgResearch since 2004, based initially at the Invermay campus near Mosgiel followed by a relocation to Ruakura campus in Hamilton in 2011. Dave has held the position of Science Team Leader for the Environmental Research Team since 2011. His research interests have focused on, soil water management, farm dairy effluent management, soil and forage response to land use intensification, and nutrient efficient practices under grazed pastoral farming systems. He has worked closely with the New Zealand dairy industry and regulatory authorities to develop improved policy and management guidelines regarding the land treatment of farm dairy effluents. In recent time Dave also led the development of an AgResearch strategy for delivering R&D into hill country. Dave's current interest is in the future of New Zealand land use and their transition to more diverse landscapes and production systems.

Dave has served on the New Zealand Society of Soil Science Council since 2008 holding the position of President for 2017/18 cycle and currently Immediate Past President. He is a joint theme leader (Innovative and resilient land and water use) in the Our Land and Water National Science Challenge.

Diana Selbie

Diana Selbie was brought up on a high country sheep and beef farm in Northern Southland. She has always had a love of the outdoors and spent summer breaks on the hills at home or working on dairy farms.

Diana completed a Bachelor of Agricultural Science degree with Honours at Lincoln University which first sparked the interest in soils as the most important resource underpinning agriculture and the environment. She then travelled to Ireland on a Walsh Fellowship to conduct her doctoral studies with Teagasc and Lincoln University on the fate of urinary nitrogen in grazed pasture systems, and was awarded a PhD in 2014.

Diana has been a scientist with AgResearch in Hamilton since 2012 and has played key science and leadership roles in the science and development of Overseer Nutrient Budgets, Pastoral 21, Forages for Reduced Nitrate Leaching and the Our Land & Water National Science Challenge. She took on the role of senior scientist in 2017 and recently relocated to the Lincoln campus in early 2019.

The primary aim of her current research is to provide farmers and rural communities with options to more efficiently manage nutrients and mitigate contaminant losses. Diana regards herself as a farm systems scientist with a keen interest beyond the farm gate and into the future.

In her spare time, Diana loves to travel, has a passion for wine, food, books, and can usually be found outdoors (tramping, sport or on the farm).

Diana regards her nomination to the NZSSS Council as a privilege and is motivated to promote soils and soil-related issues on behalf of the NZ soils community.

Tanya O'Neill

Dr Tanya O'Neill is a Lecturer in Soil and Environmental Sciences at the University of Waikato and teaches both undergraduate and graduate students. Born in the Horowhenua region, Tanya developed her passion for soil science at Massey University where she completed a BSc and MSc (Hons). After enjoying a taste of research, she worked in the Environmental Chemistry Lab at Manaaki Whenua – Landcare Research, and in 2008 was awarded the inaugural *Murray Jessen Memorial Doctoral Scholarship* to carry out a PhD programme. Tanya moved to the Waikato to work with Dr Megan Balks investigating the impacts of human activities on the Antarctic terrestrial environment, and rates of soil recovery, and has been based in the Waikato since. She has had six trips to Antarctica and is currently working on a number of national and international Antarctic-related collaborations, has contributed to policy decisions on environmental management issues, and most recently involved in an effort to undertake a baseline survey of the Scott Base environment before the major redevelopment of the New Zealand base.

Tanya is married to Trev Rhodes, the General Manager of a construction company in Hamilton, and they spend their weekends enjoying the outdoors. Tanya and Trev scuba-dive, fish and mountain bike together, and her other interests include cooking, gardening, travel, and cracking the whip when she instructs indoor cycling classes at the Waikato University rec centre!

This is Tanya's first term on the NZSSS council and she hopes to bring energy and enthusiasm to the team and is keen to engage with, and promote the care of our important soil resource, to the widest possible audience.

Brendon Malcolm

Brendon was brought up in Nelson on a mixed enterprise farm consisting of dairy cows, a stone fruit and pip fruit orchard, and boysenberries. From a young lad he had a strong interest in farming and was putting cups on cows when physically able.

Brendon went to Lincoln University in 2004 and studied a Bachelor of Agricultural Science with Honours. His initial intention was to become a dairy consultant and eventually go farming, but a taste for research during his final honours year, looking at the effect of DCD ('Eco-N') on pasture nitrate concentrations, saw him continue on in research and gain a PhD under the supervision of Professor Keith Cameron looking at the effects of pasture species composition on nitrate leaching losses. This led to a postdoctoral position at Lincoln University where he joined the Pastoral 21 research team, with a focus on dairy systems research for high productivity and reduced environmental impact.

In 2014 Brendon began a permanent scientist position at Plant & Food Research in Lincoln, which is where he currently resides. His area of research is nitrate leaching losses from forage crop systems, which largely involves quantifying nitrate leaching losses from grazed winter forage crops and identifying mitigation technologies (e.g. catch crops, soil amendments) that immobilise N and improve environmental outcomes.

Outside of work, Brendon has a love for the outdoors and sport in general; in particular, a keen hunter-gatherer both on the land and in the sea.

Brendon considers it a privilege to be on the NZSSS council and hopes that he can promote the importance of soils to a wide range of people.

Haydon Jones

I was born in Cambridge and grew-up on the family farm at Kaipaki situated just to the south of Hamilton City, on soils formed in the volcanogenic alluvium of the Hinuera Formation in the Waipa District.

An interest in physical geography at high school led me to study Earth Sciences at Waikato University. It was there that I discovered a passion for Soil Science and was

inspired to pursue a career in the field. I completed an MSc thesis on soil-landscape modelling and soil classification in a planted forest in Southland and followed up with a PhD on the impacts of forest harvesting on the performance of soil-landscape modelling techniques in a planted forest north of Auckland.

After completing my PhD, I began employment as a Soil Scientist at Forest Research (now Scion), Rotorua, in early 2005. While at Scion I worked on aspects of soil carbon stock assessment, forest management impacts, soil erosion, and land use capability assessments. In 2012 I returned home to the Waikato (and back to the family farm) to take up a position as a Soil and Land Scientist at Waikato Regional Council (WRC). The development of nationally consistent indicators and methods for regional soil and land monitoring and reporting is a key focus of my work at WRC. I also lead the Land Project within the Environmental Monitoring and Reporting (EMaR) initiative. EMaR is a joint LGNZ Regional Sector Group-Ministry for the Environment initiative that aims to provide integrated regional/national environmental data collection and accessible reporting. The EMaR Land project is embedded within the Land Monitoring Forum (LMF) a regional authority Special Interest Group.

Paul Johnstone

Paul Johnstone leads the Cropping Systems & Environment group at Plant & Food Research. His research interests cover a broad range of initiatives addressing high productivity farming systems, crops with high value traits, production footprints and resilience. He is an associate editor for the NZ Journal of Crop and Horticultural Science and a representative on the NZ-China Water Research Centre. Prior to Plant & Food Research, Paul worked at the University of Davis, California, and prior to that studied at Massey University.

Sam Carrick

Manaaki Whenua Landcare Research

Land resources were a defining part of my childhood growing up in the Manawatu. My Grandparents' Pohangina farm was governed by the high erodibility of the sand gullies, whereas down home it was the dense Pallic soils which ran the show. On our Taupo holidays it was the pumice soils that captured my attention, in those long hours waiting to hook the big trout!

Originally I left to study Landscape Architecture at Lincoln Uni, but drifted off to work for a few years. Returning to study in the mid 1990's I stumbled on soil science, and the light bulb clicked on! At last I'd found something that I felt at home with. In the late 1990's I headed first to work on completing the regional lowland soil survey for Southland, then joined Manaaki Whenua to complete the Otago region. In the mid 2000's I returned to Lincoln to complete my PhD in soil water physics, before returning to Manaaki Whenua in 2009.

My work since then has been split between pedology and soil physics work, across a range of collaborative multi-agency projects, as well as part time teaching in the Lincoln University Soil and Physical Sciences Department. Since 2017 I have moved into science leadership, leading the *Characterising Land Resources* Portfolio at Manaaki Whenua. This portfolio is responsible for nationally significant soil and land databases, such as S-map, the National Soil Data Repository, as well as the Land Resource Inventory and Land Use Capability classification.

Thankfully my soil science light bulb that flicked on 20 years ago is still gaining more energy, as I keep learning each new fascinating aspect of the world under our feet and the great influence it has on human society.

Chris Anderson (twitter @chrisNZscience)

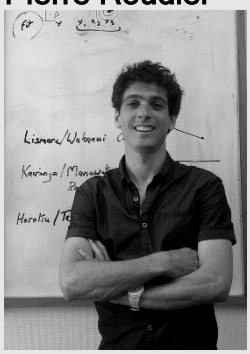
Christopher Anderson (Chris) holds business and academic positions in several countries. He works at the interface of science, technology, community development and business to promote agricultural development in mining communities. In New Zealand he holds the position of Professor in Environmental Science at Massey University, and is the Group Leader Environmental Sciences at the School of Agriculture and Environment as well as the Acting Director of Massey's FLRC. He is also a Director of the New Zealand company Croesus Projects Ltd. As a result of his international activities he holds the position of Adjunct Professor at the Institute of Geochemistry of the Chinese Academy of Sciences and at the Faculty of Agriculture at the University of Mataram in Indonesia. He leads an active and global research group investigating the interactions of trace elements and contaminants with the environment. His projects study heavy metals, organic pollutants such as dioxin, and essential micronutrients.

Chris completed his PhD at Massey University in New Zealand. During his doctoral research he developed the concept of gold phytomining, and went on to establish the first company in the world offering commercial gold phytomining services (through Croesus Projects Ltd.). Today Chris is involved with phytomining and large scale environmental impact assessment and remediation projects in China, Indonesia as well as NZ. He works with the Government of Indonesia and international donors on the issues of pollution and mining efficiency at artisanal and small-scale gold mines, and leads a significant NZ-led initiative in east Indonesia to

increase the production and agribusiness capability of small-scale, generally subsistence farmers (www.ifsca.nz). He actively seeks opportunities for in-country entrepreneurs to create wealth from innovative biomass technologies, and from safe and nutritious foods.

Chris manages an active teaching portfolio to support his research and commercial activities. At Massey University he leads the Environmental Science major of the BSc degree. This programme prepares graduates for careers that will manage the impact of New Zealand's economic development on the environment. The preparation of skilled graduates for the work force who can critically assess and provide informed commentary on key issues such as water quality, land degradation, soil contamination and land-use suitability is a hallmark of Massey's Environmental Science and Environmental Management programmes.

Pierre Roudier



Dr. Pierre Roudier is a soil scientist, proximal and remote sensing specialist, and spatial modeller at Manaaki Whenua – Landcare Research in Palmerston North. Pierre studied agriculture at Montpellier SupAgro, in France, and holds a MSc in Information Technologies Applied to Agriculture and Environment, and a PhD in applied remote sensing.

His main area of research is *pedometrics*, the use of quantitative methods for the study of soil distribution and genesis. He is passionate about developing innovative approaches that leverage the recent advances in machine learning and soil sensing, so to provide quantitative soil information to a wide range of soil stakeholders.

Pierre also has a keen interest in Antarctic soils, where he applies pedometrics so map some of the key chemical properties of soil found in the ice-free areas of the continent. He has been part of four successive field events across the Ross Sea Region. Regardless of the application or the scale, Pierre believes that mapping its main properties is the first step towards protecting our precious soil resource – and its sustainable management.

Pierre has been involved in IUSS activities since 2011. He is an Advisory Board member of the Commission 1.5 on Pedometrics, a vice-chair of the Global Soil Mapping Working Group, and a regular member of several other Working Groups, including Soil Information Standards and Proximal Soil Sensing.

Pierre has a passion for science communication, and believe it is our duty, as soil scientists, to carry the voice for our soils. He tweets about his research at @pierreroudier, and was a regular host of RNZ's Nights science segment talking

about soils and soil science. In 2015 he received Landcare Research's Distinguished Service Award for his science communication efforts.

Aside from the research he leads at Manaaki Whenua, Pierre also holds a Principal Investigator position with Te Pūnaha Matatini, a Centre of Research Excellence on complex systems and networks hosted by the University of Auckland.

Aside from work, Pierre is most happy outdoors, and can be found kite surfing when it's windy, or mountain biking if it's not.

Society News: Awards

Celebrating Success – Recipients of the NZSSS Awards for 2018

Compiled by Dr Brendon Malcolm, NZSSS Awards Convenor (2017-present)

The 2018 biennial NZSSS conference held in Napier was again an excellent opportunity for the Society to honour and celebrate the success of those who have made significant contributions to soil science – on behalf of Council, congratulations to all those who received awards. The awards presented and the recipients of those awards are briefly profiled below.

Fellowship of the New Zealand Society of Soil Science

Fellowship of the New Zealand Society of Soil Science is an honour conferred for distinction in any or all of the following areas; research, technology, teaching, extension, and/or the advancement of soil science.

In 2018, **Dr Denis Curtin** was elected Fellow of the Society. Denis is a long-serving soil scientist at Plant & Food Research and is highly respected by his peers, both nationally and internationally. Throughout his prolific career, Denis has published more than 120 scientific papers which have received over 5500 citations, the most highly cited of those papers receiving over 400 citations.

Much of Denis's recent research has focused on determining the key processes and interactions that affect soil organic matter in order to refine management practices to improve nitrogen use efficiency and reduce nitrogen losses. His research has made substantial progress in identifying mechanisms and understanding the processes that influence soil organic matter mineralisation, including the effects of temperature, moisture, soil physical disturbance and pH.

Photo: Paul Johnstone

Denis has also had a long-standing interest in the physical and chemical fractionation of soil organic matter, in part to improve the modelling of soil organic matter based on measurable, rather than conceptual, pools. In general, this research has shown that the organic matter associated with different soil particle size fractions is not homogeneous, and each fraction contains components of both recalcitrant and biologically active organic matter. Given these observations, recent research has emphasised the role that soluble organic matter plays in regulating soil C and N mineralisation and the mechanisms that underpin organic matter solubility. This work has led to a recent focus on developing improved methods to measure potentially mineralisable nitrogen in soils and applying this to in-field predictions of nitrogen mineralisation to improve nitrogen fertiliser forecasting and nitrogen management on-farm.

The Norman Taylor Memorial Award

The Norman Taylor Memorial Award (Lecture) is awarded by the President of the NZSSS in recognition of outstanding contributions to soil science in New Zealand. The 2018 recipient of the Norman Taylor Memorial Award was **Dr Ants Roberts**. Ants is Chief Scientific Officer of Ravensdown is very highly regarded in the field of soil science by his peers. One of Ants' close-working colleagues quotes "He is known for his ability to convey complex science in a simple manner, delivered in a theatrical entertaining way, and thus, keeping the audience fully engaged." We had great pleasure in witnessing this skill of Ants' first hand at the conference with his Lecture, *'Is disruption the new black? A luddite's view'*.

Photo: Paul Johnstone

Ants' professional specialities include the areas of soil fertility, pastoral agronomy, heavy metal accumulation, waste utilisation and disposal, soil quality indicators, science management, and science learning and training. As Chief Scientific Officer, he trains the approximately 70 field staff within Ravensdown in soils and agronomy. Ants works closely with the Ravensdown field team on shareholders' properties where he firmly believes there is significant opportunity for value add to their businesses through the best use of products and services offered by the company. In addition, he spends a considerable amount of time representing both scientific and farmer interests in resource management hearings and in dealings with regional councils and industry groups.

The L.I. Grange Medal

The L.I. Grange Medal is awarded for outstanding service to New Zealand soil science and commemorates Dr Leslie I. Grange's extraordinary leadership and service to New Zealand soil science.

Photo: Paul Johnstone

In 2018, the recipient of the Grange Medal went to **Professor Mike Hedley**. Mike is an internationally recognised researcher, teacher and thought-leader who has made an outstanding contribution to the discipline of soil science for more than 40 years. Mike's research interests are in the areas of soil nutrient cycling and sustainable nutrient management in agriculture, and span from methodology development, soil processes, fertiliser technologies and fertiliser contaminants, through to agricultural greenhouse gas emissions and mitigation, and farm-scale systems research. Mike has authored 136 peer-reviewed journal articles, and numerous conference papers, research reports and book chapters.

Mike has demonstrated the highest commitment to the teaching of soil science through his very active involvement in under-graduate courses at Massey University and supervision of post-graduate students. He started as a Lecturer in Soil Fertility in 1983, and since then has developed and taught many university undergraduate and postgraduate papers and has supervised a large number of soil science postgraduate students; including over 30 PhD students.

Mike has also led the development and teaching of professional development courses in sustainable nutrient management, and Greenhouse gases in agricultural systems, which have been attended by more than 3,000 participants since 2002. Until July 2018, he led the Soil and Earth Sciences Group and the Fertilizer and Lime Research Centre at Massey University, which together have a combined staff of over 30. Mike convenes the organising committee for the Fertiliser and Lime Research Centre's annual workshop, which has grown to be the single largest national scientific conference focused specifically on nutrient management in agriculture.

Thank you for the Grange Medal - message from Mike Hedley

The Grange Medal announcement at the NZSSS Conference Dinner was a huge surprise for me and of course a great Honour, which I will value with pride. The NZSSS Council and my colleagues had done a great job of keeping it secret, despite Carolyn's role on the conference organising committee. Somewhat shocked -- I hope my acceptance speech about the role of NZ soil scientists in meeting the challenge of GHG emissions reduction for New Zealand and the world did not dampen the splendid dinner celebrations at the Mission Winery.

A big thank you to the Conference organising committee, everyone I met really enjoyed the Hawkes Bay conference and spectacular venue and weather. Word has spread, even Elton John has the venue booked twice now!

Thank you to the NZSSS Council for my award – and thank you to all my colleagues that have helped make the contribution to soil science that the Grange Medal recognises.

I have had a long association with Massey University since joining the Soil Science Department for my PhD studies in January 1975. My most productive time was definitely as Director of the Fertilizer and Lime Research from 1998 onwards, which has been recognised by the New Zealand Fertiliser Industry Association.

http://www.fertiliser.org.nz/Site/news/articles/retirement-tribute-professor-mike-hedley.aspx.

The Fertilizer and Lime Research Centre (FLRC) could not have achieved the successes in research and professional development training without the huge contributions from other Massey colleagues both academic and technical staff. Notably over time Keith Syers, Bob White, Russ Tillman, Paul Gregg added their flavour to the FLRCs research focus (from fertiliser design and evaluation to environmental research) with major contributions from Nanthi Bolan, Surinder Saggar, P. Loganathan, Dave Scotter, Jay Howes and current staff Chris Anderson, Marta Camps, Dave Horne, James Hanly, Lucy Burkitt, Mike Bretherton, Ranvir Singh, Christine Christensen and Roberto Calvelo-Pereira, Peter Bishop and Jeya Jeyakumar.

In recent times much of our research into the impact of dairy farm systems on water quality and the fate of fertiliser borne fluoride and cadmium in pastoral agriculture could not have been achieved without great technical assistance from Bob Toes, Glenys Wallace, Ian Furkett, Ross Wallace and Quang Mai, working in conjunction with Massey University Farm staff and our CRI collaborators.

A particular thankyou to Lance Currie, who greeted me on the day I arrived at Massey University in 1975 and with whom I formed a strong working relationship and who needs to be recognised for his major contribution to the smooth operation of FLRC's research and Professional Development (PD) teaching programmes and the organisation of the 32 annual FLRC workshops (https://www.massey.ac.nz/~flrc/). Hopefully, by the time you read this, we will have surprised Lance, with a tribute, at the 32nd FLRC workshop dinner.

Thank you to all my hard-working postgraduate students that have pushed the boundaries of soil science from the test tube to the infertile soils of Myanmar. Each brings special memories that I carry into my retirement - I hope you all got a feeling of satisfaction in making your contributions to science- whether a problem was solved or simply a new problem was found!

Most importantly I would like to thank Carolyn for allowing me long hours in the laboratory when our family was young and all the support for the nights and weekends spent writing research proposals and reports, or marking assignments and theses. We have also done some great soil carbon research together. Apologies to Frances, Paul and Joanne for all the boring soil science discussed at meal times.

Here's to those-- "Flasks all in line they look so fine all filled with blue solution"

Cheers
Mike Hedley

The M.L. Leamy Award

The M.L. Leamy Award commemorates the outstanding ability and contributions to New Zealand soil science of Michael Lucas Leamy, and recognises meritorious contemporary work. The award is made to the author or authors of the most

meritorious New Zealand contribution to soil science, published in the past three years.

In 2018 the Society had pleasure in presenting the Leamy award to **Dr Jiafa Luo**.

Photo: Paul Johnstone

Jiafa is a scholar of international standing and has been widely recognised for his research on nitrogen cycling and nitrous oxide emissions. Jiafa has a very impressive publications record, and during the last three years he has authored and co-authored more than 50 high-quality, peer-reviewed papers in international journals. In 2017, he was the editor of the book Greenhouse Gas Emissions and Nitrogen Losses from Grazed Dairy and Animal Housing Systems. The research findings presented in his long list of recent publications will have significant impacts on improving the national greenhouse gas inventory calculations and on targeting nitrous oxide mitigations.

The L.C. Blakemore Award

The L.C. Blakemore Award honours the outstanding ability and contributions to New Zealand soil science of Les Blakemore and recognises meritorious contemporary work by technicians.

The recipient of the Blakemore award for 2018 was **Brian Moorhead**.

Photo: Roland Stenger

Brian has been working as a technician for Lincoln Agritech since 2000, initially in the Supply Chain Systems Group, and since 2008 in the Environmental Research Group. During this time, he has made tremendous contributions to various projects on optimising agricultural and horticultural land use and minimising negative environmental effects. Accordingly, he was the natural choice as 'Operations Manager' for the highly sophisticated and technically challenging 'Spydia' vadose zone research facility in the Lake Taupo catchment.

Brian is known for his willingness to share his knowledge with others, and has had a very important role in mentoring new technicians and training them in the specifics of field and soil hydrology. He has required a special emphasis on correct techniques and recording of information to account for the complexity and spatial variability in subsurface flow and soils investigations.

The Bert Quin Postgraduate Bursary

The Bert Quin award recognizes the efforts and present, or likely, contribution to New Zealand soil science arising from a Doctorate study. Eligible candidates for this award must be 3rd year PhD students working on the properties, productivity or sustainability of NZ's soil and land resources.

Photo: Paul Johnstone

T
he recipient of The Bert Quin award for 2018 went to **Thangavelautham Geretharan (Gere)** of Massey University.

Gere's research focusses on soil fluorine. He recently published a paper in the Microchemical Journal entitled "Defining a standard method to measure the total and bioavailable concentration of fluorine in New Zealand soils", which is now being assessed by Hill Laboratories, Eurofins and ARL for adoption as a New Zealand standard technique to analyse the fluorine concentration in NZ soils. The significance of his research saw him awarded the Ravensdown Agricultural Research Scholarship in both 2017 and 2018.

The Morice Fieldes Memorial Award

The Morice Fields Memorial Award recognises a PhD theses from the previous calendar year of exceptional merit. In 2018 the Society awarded this to **Monica Bucci**, Lincoln University, for her thesis: '*Lessons learned from liquefaction of the Canterbury Earthquake Sequence (2010-2011) to inform paleoliquefaction studies'*. Judges noted that the thesis was very comprehensive and well written, demonstrating an outstanding level of expertise in the area of pedology and geomorphology, and offering a better understanding of liquefaction dynamics.

The Sir Theodore Rigg Memorial Award

Photo: Paul Johnstone

The Sir Theodore Rigg Memorial Award recognises a Masterate theses of exceptional merit from the previous calendar year. **Olivia Petrie**, University of Waikato, was the recipient of The Sir Theodore Rigg Award for her thesis: '*Temperature and moisture sensitivity of soil microbial respiration in adjacent irrigated and non-irrigated soils'*. It was noted that the thesis demonstrated a wide breadth of knowledge and skills, and was highly relevant on the issues of carbon losses under irrigation.

The T.W. Walker Student Prizes

The T.W. Walker Prizes honour the outstanding ability and contributions to teaching and research to New Zealand soil science of Professor T.W. Walker and recognise contemporary work by students. Prizes for the best student oral and poster presentations at the Society's 2018 conference were awarded.

Photo: Paul Johnstone

Akinson Tumbure, Massey University, was the recipient of the best student oral presentation for 2018 for his talk entitled: *'Using recycled glass to increase P availability of insoluble Dorowa phosphate rock'*.

Photo: Paul Johnstone

The recipient of the best student poster presentation was **Kirsten Duess**, Lincoln University, for her poster entitled: *'The influence of artificial subsurface drainage on soil*

Society News: 2018 Conference

Impressions of first NZSSS conference, Napier 2018

Anders Crofoot

The NZSSS conference in Napier this year was a great experience. I have been a member of the NZSSS for many years. I enjoy reading the newsletter and papers, but the annual conference usually conflicted with lamb weaning so I have been unable to attend. This year, due to a poor spring we weaned lambs early and I finally made it.

I attend quite a few conferences as I find they are a great way to learn new things and meet people who are leading their fields. The organisation of the conference was excellent. The selection of topics most stimulating. I find concurrent sessions a bit frustrating when one must choose between different sessions. When they are well run (it was), hopscotching between sessions for papers alleviates some of that.

I was very encouraged by the number of young people attending the conference. Having felt that NZ's soil science capability had been gutted by past policy decisions, it was pleasing to see there are new enthusiastic coming into the field doing interesting research.

New Zealand Soil Judging Competition 2018

December 1-2, Matapiro Station, Hawke's Bay
Reece Hill, Carol Smith and Sharn Hainsworth

On 1st December 2018, soil science students from Massey, Lincoln and Waikato universities gathered for the first New Zealand only Soil Judging Competition held at Matapiro Station in Hawke's Bay. This soil judging competition followed on from the competition held in Wanaka, prior to the Queenstown conference in 2016.
For most of the students this was their first ever soil judging competition and for many the first time they had described a soil profile. The competition format is for a practice day, followed by the competition day. During the practice day, the teams are able to learn about the soils at the competition venue and to hone their skills in team work and profile description. Sharn Hainsworth was on hand to guide the students through the pedology.

Matapiro Station provided a great location. The historic station (and impressive homestead) was selected as the location for the judging because of its range of soils and landforms, typical of large parts of the Heretaunga and Ruataniwha Plains.

The original Matapiro Soil Series is named after a Duric Perched Gley Pallic Soil described within the boundaries of the station in the early days of New Zealand soil

survey. Other large old stations and landmarks nearby were also used for naming soil series such as the Okawa and Crownthorpe.

Practice day was held Saturday. Teams had 90 minutes to compete a site assessment, describe a soil profile and make site interpretations based on their observations, and also to classify the soil. While this may seem sufficient time to describe a soil, it requires practice and team work to complete all the tasks on time. It was impressive to see the teams working out their roles and timing to get through all the components of pit competitions. Strong organisation and team work are essential as well as good soil knowledge.

Competition day arrived. With the threat of rain over the competition weekend (as well as a decent drop of rain filling one of the pits before the weekend) we set up the competition pits in the morning, cleaning the faces and bailing water. We were very fortunate, the rain held off making for a pleasant competition.

Photo 1: All teams on practice day

There were three competition pits; two team pits and an individual pit. The pits represented the landscape across the station, including loess covered rolling downlands containing Duric Perched Gley Pallic Soils, an aggradational river terrace (Ohakea or “Ripia” aged terrace) covered in a thin layer of tephric loess, that contained a complex of Allophanic Brown and Duric Perched Gley Pallic Soils, and an older Holocene-aged river terrace sporting alluvium with a twist, a perched water table over a partial fragipan -after much debate, named an Immature Pallic Soil. Needless to say, the soils provided a good challenge for the competitors as well as plenty of discussion amongst the judges.

Winners were announced at the NZSSS Soils2018 Conference BBQ Function on the Monday night. The results were very close. The team event was won by the

University of Waikato team of Anne Wecking, Matthew House and Annette Carshalton.

Photo 2: University of Waikato team receiving the NZSSS SJC cup for Team winners

The individual winner was Julie Gillespie (Lincoln University). Congratulations to the winners and well done to all the competitors for participating with such enthusiasm.

Photo 3: Julie Gillespie, SJC Individual winner 2018

The feedback from students was that the competition was overwhelmingly worthwhile and heaps of fun. They particularly noted the invaluable experience of getting their hands dirty describing soils in the landscape, and in an unfamiliar region.

A big thank you to our soil judges (Alan Palmer, Carol Smith and Scott Fraser), team coaches (Tanya O'Neill, Megan Balks, Roger McLenaghen and Mike Bretherton), competition organisers (Reece Hill, Sharn Hainsworth, Tim Norris and Veronica Penny), our sponsors (Manaaki Whenua, NZSSS, Landsystems and Hawkes Bay Regional Council) and of course Matapiro Station (especially Michael Lowther) for providing the great soils.

News from the Regions

Waikato/Bay of Plenty

Waikato University

Waikato University had a busy end of the year with the NZSSS conference in Napier and a number of Antarctic projects over the summer.

Scott Base redevelopment

Antarctica New Zealand are commencing work towards a major redevelopment of Scott Base and preliminary work is being undertaken to gather baseline data for environmental impact reporting. *Tanya O'Neill* and *Clare Beet* travelled to Scott Base in January and marked out 25 long-term monitoring plots, sampled soil for chemical attributes; undertook an invertebrate survey; and installed 12 dust collectors (Figure 1) to investigate baseline dust transport around the base vicinity. For more on the Scott Base Redevelopment project click here: http://www.antarcticanz.govt.nz/scott-base/scott-base-redevelopment/

Figure 1: One of the dust collectors Tanya O'Neill is helping install as part of the baseline environmental monitoring for the Scott Base redevelopment. Photo: Tanya O'Neill.

Soil permafrost temperature monitoring

Chris Morcom and Pierre Roudier (Maanaki Whenua - Landcare Research) travelled to Antarctica to undertake the annual maintenance and data down-load for our 9 soil climate stations (Figure 2), four of which have been running since 1999. They also downloaded the two 30 m borehole temperature strings which we run in collaboration with Mauro Guglielmin from Italy. The data contribute to the CALM (circum-polar active layer monitoring) programme as well as to the GTN-P (Global Temperature Network-Permafrost).

While they were "on the ice" Chris and Pierre also collected samples from 34 locations dotted across the McMurdo Dry Valleys. These samples will fill major gaps in the existing soil sample collection of the region, in order to calibrate a digital soil model of functional soil properties of the region.

Figure 2: Chris Morcom and Pierre Roudier downloading the soil climate monitoring station at Marble Point. Photo: Jon Tyler.

Waikato University report of the New Zealand Soil Science Society Conference, Napier, December 2018

Soil judging competition

Three Waikato University graduate students (Anne Wecking, Annette Carshalton and Matt House) participated in the 2nd New Zealand soil judging competition on a farm at the foothills of the Kaweka ranges (Figures 3 and 4). The event kicked off with a practice day on Saturday 1 December and the competition on Sunday 2 December. Teams had to complete a scorecard by describing the site characteristics and soil profile morphology, then to estimate certain soil profile characteristics such as hydraulic conductivity, effective soil depth, and soil drainage class. They also estimated from their soil descriptions the soil water holding capacity. When teams were "out" of the pit, they could complete other tasks on the scoresheet such as texture, colour and structure on the samples they collected from the pit face. A further

step was to check against a table of suitability interpretations for three different land uses, and assess the suitability of each soil for that land use. Finally, they had to classify the soil to sub-group level in the NZSC. Our three-person Waikato University team won the very close team competition (against Lincoln and Massey Universities), and Matt House came second place in the individual competition. We would like to extend our thanks to all those involved in organizing such a wonderful event. The next competition will be at the joint New Zealand/Australian Soil Science Society conference in Cairns in 2020.

Figure 3: Anne Wecking, Annette Carshalton and Matt House in competition mode. Photo: Tanya O'Neill.

Figure 4: Team trophy presented by Dave Houlbrooke to Anne Wecking, Annette Carshalton and Matt House. Photo: Tanya O'Neill.

Conference

The conference dinner was a great opportunity for all Waikato University graduates in attendance to gather for a photo outside the beautiful Mission Estate (Figure 5).

Figure 5: Decades of Waikato University graduates in soil-related sciences. Photo: Tanya O'Neill.

We had other successes at the conference with *Megan Balks* (Adjunct Senior Research Fellow) announced President of the New Zealand Soil Science Society (Figure 6), *Tanya O'Neill* elected to council, and former student, *Olivia Petrie,* receiving the Sir Theodore Rigg award for her MSc thesis: "Temperature and moisture sensitivity of soil microbial respiration in adjacent irrigated and non-irrigated soils". We also had a number of postgraduate students giving oral and poster presentations including *Thomas Corbett, Kristyn Numa, Jasmine Robinson, Anne Wecking, Aaron Wall, and Annette Carshalton*.

Figure 6: The handover, incoming president Megan Balks and immediate-past president Dave Houlbrooke. Photo: Tanya O'Neill.

Visitors from University of Wisconsin, Platteville

David Lowe and *Megan Balks* hosted an agronomy-focused soil science group from University of Wisconsin at Platteville, USA, for three days from 15-17 January 2019. Led by Prof *Chris Baxter* and *Heidi Geske*, the 'Winterim 2019' group comprised eight students who undertook a 17-day field trip through New Zealand in January. Chris had previously led a group through New Zealand in December 2016 following the joint Australia-New Zealand soils conference in Queenstown. In their three days in the Waikato-Bay of Plenty, the group visited (on day 1) a dairy farm on Pirongia (with *Keith and Margaret Ormsby*) (Figure 6) and a sheep and beef farm on Maungatautari, taking in the conservation work on the Maungatautari 'ecological island' as well as other information (with *Bill and Sue Garland*).

Figure 6: Tour group and hosts sheltering in the milking shed on the Ormsby farm, Mt Pirongia, during the only rainfall event of the entire month of January 2019.

On day 2, the group enjoyed the hospitality and culture of Māori people at Te Puia (Whakarewarewa), saw and appreciated the multi-layered Rotomahana soil in Brett Road near Mt Tarawera (Figure 7), then proximal tephra deposits near Blue Lake, before finishing the day in the welcome coolness of the Redwood Forest in Rotorua.

Figure 7: Engaging with the past as shown by David Lowe alongside the spectacular multi-layered profile of the Rotomahana soil on Brett Rd at Lake Rerewhakaaitu near Mt Tarawera. Photo: Chris Baxter.

On day 3 they inspected a Kainui soil on Raynes Road (at Rukuhia) and then a Rukuhia soil on peat on Moanatuatua bog (Figure 8), looked behind the scenes with Blueberry Country manager *Warrick Macdonald* at the packing operation near Ohaupo, had a bush walk on Pirongia, and finally visited the Te Parapara ancient Maori garden at Hamilton Gardens (Figure 9) where *Wiremu Puke* explained the significance, development, and functioning of the special anthropic soils in the gardens. As always, we found the American students to be polite and engaging and they enjoyed their visit.

Figure 8: On the Moanatuatua bog with Rukuhia soils underfoot and a Blueberry Country crop harvester on the surface. Chris Baxter and Heidi Geske at right. Photo: David Lowe.

Figure 9: Kumara growing at Te Parapara garden at Hamilton Gardens. Photo: David Lowe.

Louis goes to Colombia

Louis Schipper visited Colombia in February as part of a joint meeting of the Global Research Alliance and CIRCASA (Coordination of International Research Cooperation on soil CArbon Sequestration in Agriculture). The meeting was based at the CIAT Research Centre (Figure 10) between Cali and Palmira. There was a large focus on a global effort to eventually develop an international research consortium to investigate increasing and maintaining soil carbon as one mitigation strategy. Louis presented at the GRA meeting on New Zealand's work. Attendees were from all around the world and the discussion was very broad. The facilities and hosts were tremendous. Afterwards a small group had a tour of the sights of Cali led by *Ngoni Chirinda* (Figure 11).

Figure 10: Entrance to CIAT Research Centre. Photo: Louis Schipper.

Figure 11: Cristo Rey that looks over Cali. PIctured (left to right) are Pete Smith, Arezoo Taghizadeh-Toosi, Jean-Francois Soussana, Cristina Arias-Navarro, Louis Schipper and Ngoni Chirinda.

PEATWISE: Wise use of drained peatlands

Dave Campbell is leading the New Zealand (NZ) component of a large international research programme to improve our understanding of greenhouse gas emissions from drained peatlands and test potential mitigation methods that will reduce negative impacts while maintaining production. The PEATWISE consortium consists of teams across six northern European countries, plus the NZ component which is funded through MPI. The NZ focus is on peatlands drained for dairy farming. In 2018 we established two research sites with contrasting drainage management on neighbouring farms within the Moanatuatua peatland. Research activities include two eddy covariance (EC) systems measuring CO_2 and H_2O fluxes with a wide range of soil, atmosphere and hydrological variables also being measured. Pasture production is being measured to enable the effects of water table depth and soil moisture to be determined. Water table manipulation is often cited as a key mitigation measure to reduce net CO_2 emissions in drained peatlands. However, there are large practical difficulties is being able to do this.

At one of the research farm sites, we have also installed an Aerodyne quantum cascade laser instrument that enables us to measure emissions of N_2O and CH_4 using the EC method. So far, very little is known about N_2O emissions from NZ's farmed peats. The European experience has shown that significant emissions of

methane are associated with drainage ditches and portions of fields with saturated soils. One of our goals is to improve NZ's GHG inventory methods for drained peatlands.

Two MSc students have joined our project (Figure 12). *Georgie Glover-Clark* is investigating the spatial patterns and drivers of water table depth and soil moisture in these deep peat soils, and the impacts of hydrological variation on CO_2 exchange and pasture production. *Jacob Hamill* will be looking for evidence of soil- and drainage-ditch generated methane hotspots, using a combination of static chamber measurements and EC.

In parallel work, we are collaborating with Waikato Regional Council and Manaaki Whenua Landcare Research, who are developing a regional peat surface subsidence monitoring network. Some of the detailed work will be co-located with our research sites (Figure 13).

Figure 12: Georgie and Jacob measuring water levels along a transect at Gamma Farm.

Figure 12: Chris Morcom at the Gamma Farm EC site. Instruments on the right measure CO_2 and H_2O fluxes, with a sample tube delivering air to the quantum cascade laser housed in the large temperature-controlled box, left.

Lincoln Agritech

Our Hamilton team recently hosted a group of Irish catchment management experts working on the implementation of Ireland's latest river basin management plan. An overview presentation given by Roland Stenger triggered lively discussions, highlighting both similarities and differences between current issues in Ireland and Aotearoa – New Zealand. While our Transfer Pathways Programme (2015-2018) had been developed taking a substantial body of earlier Irish research into account, our discussions revealed that some of the tools we have developed in recent years might also be useful in the Irish context.

Fig. 1: Bernard Harris (Agriculture Ministry), Margaret Keegan (Local Authorities Waters Programme), Roland Stenger (Lincoln Agritech), Jenny Deakin (EPA), and Noel Meehan (Agricultural Sustainability Advice and Support Programme). (Photo: Aldrin Rivas).

The first SkyTEM flights in NZ, introduced as part of our new Critical Pathways Programme, have just been completed. The support provided by our collaborator Prof Esben Auken from Aarhus University (Denmark) allowed the helicopter-borne transient electromagnetic surveys of the Waiotapu Stream and the Piako River headwater catchments to be specifically optimised for our research project. Our Environmental Data Analytics Science Leader Mike Friedel will now put his hydrogeophysics expertise to good use and start analysing the collected 'Big Data' in conjunction with a wide range of other data affecting vadose zone and aquifer characteristics.

Fig. 2: SkyTEM survey being conducted in the Piako River headwater catchment in February 2019 (Photo: Aldrin Rivas).

Manaaki Whenua - Landcare Research

The Soils and Landscapes team at Manaaki Whenua – Landcare Research recently held a team meeting at Arthur's Pass, with members of the team travelling predominantly from Hamilton, Palmerston North and Lincoln. We were treated to a series of stops on the drive between Christchurch to Arthur's Pass where we discussed the landscape, geology and erosion processes featured through this beautiful part of New Zealand (Photos 1 and 2).

Photo 1 and 2: The view at Porters Pass and the team enjoying the chance to stretch our legs at Cave Stream Reserve. (Photos: Suzanne Lambie).

This was followed by a couple of days of communal living, whereby the team showed significant statistical clustering of the prevalence, with no gender bias, of snoring.

We also participated in workshops to enable better understanding of the research being conducted within our team and future opportunities (Photos 3 and 4).

Photos 3 and 4: The Soils and Landscape team at Manaaki Whenua – Landcare Research and workshops in action. (Photos: Anya Gregg).

Manawatu

Plant & Food

We farewell our summer student **Victoria Buckley** who has been working on Te Ao Turoa- Intergenerational Resource Sustainability supervised by **Karen Mason**. Victoria's part of the project was to look at the food preference of native bird nectar eaters, Tui and Korimako. They selected 3 sites, two with private orchards and the other with a few fruit trees. Across these sites they set up 7 feeding stations. To prepare for the experiment they caught and banded wild birds so they could identify at least some those visiting the feeding stations as well as collect data for the wider project. They also had to train the birds to use the feeding stations. Each day of the experiment, the birds were given fruit, sugar water and Wombaroo (a complete food with all the protein fat and carbohydrates a nectar eater needs). Trail cameras with a motion trigger were used to capture when birds visited the feeders.

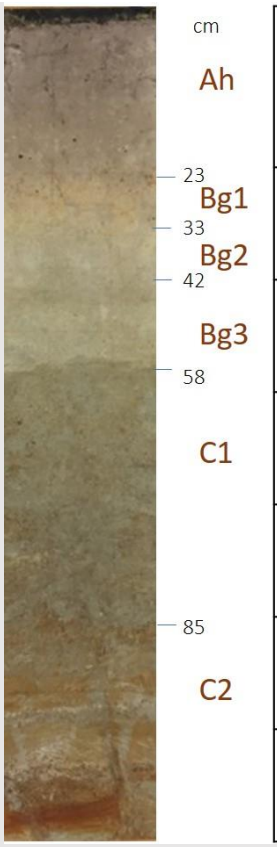
Victoria and Karen Mason banding birds.

The set-up of a feeding station.

Manaaki Whenua – Landcare Research

Results of the 2018 NZSSS Conference Great Soil Monolith Competition

Manaaki Whenua held a “Guess the Soil” competition at the 2018 NZSSS Conference held in Napier, Hawkes Bay. Competitors were asked to guess the soil type, age, land use, Land Use Capability class, topsoil percent organic carbon, profile available water (to 100 cm) and classification by investigating a soil monolith.



Soil type	Kairanga silt loam over sandy loam
Age of Soil	< 200 year
Land Use	pastoral
LUC Class	2(w)
Organic C in topsoil	2.3 %
PAW100	161 mm
Soil Classification	Typic Recent Gley

Competition was intense – and we are very proud to announce that the joint winners, whose answers were closest to the correct ones are:

- **Annette Carshalton**
- **Jonno Rau**

We obviously have two budding pedologists here – and we congratulate Annette and Jonno on their great achievement!

The photos capture some of the intense competition that occurred.

The Great Soil Monolith Competition attracted a wide range of experts to have a go at guessing the identity of the soil

Long after the first day of conference proceeding had finished at the Napier NZSSS conference – the Great Soil Monolith Competition continued - way into relaxation hours!

Massey University

The 32nd Annual Workshop was held by the Fertilizer and Lime Research Centre (FLRC) on the 12th-14th of February 2019 and was a very well attended and productive event. The organisers continued with the sustainable farming theme from the past several years, with the title of the workshop this year being 'Nutrient Loss Mitigations for Compliance in Agriculture'. The Organisers constructed sessions by inviting several people to give presentations relating to the practical implementation of policy in several regions of New Zealand. This included people engaged in policy rollout, consultants presenting case studies and farmers giving very practical perspectives.

An invitation to speak was sent to Dr Jenny Deakin from Environmental Protection Agency, Ireland and, such is the reputation of the FLRC Workshops, she distributed the information to colleagues and we had three additional Irish science/policy personnel who chose to pay their own way to attend this event. Jenny Deakin gave a keynote address titled 'The Key Water Quality Issues in Ireland and the Irish River Basin Management Plan'. This talk had close parallels with research and policy issues in the New Zealand agricultural sector and provoked very useful discussion among delegates at the Workshop.

A similar situation occurred when we invited Dr Flemming Gertz from SEGES in Denmark. Two students from Aarhus University in Denmark accompanied Dr Gertz with travel support from their own University and gave poster presentations, which again paralleled research work being conducted in New Zealand. Dr Gertz' presentation was titled 'Engaging Farmers in Environmental Management in Denmark'. An extremely interesting presentation by Dr Peter Thorburn from CSIRO in Brisbane was titled 'Digital Agriculture - Helping Farmers Reduce Impacts of Cropping on the Great Barrier Reef'.

In all, there were 90 presentations (both oral and by poster) during the three days of the workshop and more than 260 delegates, representing universities, CRI's, fertiliser industry, private consultancies, DairyNZ, Fonterra, regional councils and national policy-makers in New Zealand attended.

Proceedings of the Workshop will be available online before too long (flrc.massey.ac.nz).

The International speakers enjoyed a week of Manawatu summer sunshine – a welcome respite for most from the Northern Hemisphere winter. Left to right: Flemming Gertz (Denmark), Jenny Deakin (Ireland), Peter Thorburn (Australia), Noel Meehan, Margaret Keegan and Bernard Harris (Ireland).

Thoughts on the Napier conference:

Thangavelautham Geretharan (Gere) PhD student from Sri Lanka at the School of Agriculture and Environment, Massey University under the supervision of Professor Christopher W.N. Anderson, Dr Paramsothy Jeyakumar (Jeya) and Dr Michael Bretherton.

The New Zealand Soil Science Society (NZSSS) Conference which was held during December 2018 in Napier is one of the most memorable events of my academic career. I participated in the soil judging competition arranged by the NZSSS and this was an event which helped me to interact with soil science students and academics. This learning by doing experience strengthened my skills and knowledge related to pedology. The NZSSS Conference provided other students and I with an opportunity to join field visits which highlighted to us regenerative farming, a concept maintaining balance relationship between nature and production. I was very honoured to have my research recognised at the conference through the award with Bert Quin Postgraduate Bursary. The award was presented at the Conference dinner in front of New Zealand Soil Scientists. I was delighted to receive this award from the NZSSS which recognises the contribution to New Zealand Soil Science from a PhD study.

The experiences from the conference and the award will definitely be useful for my future academic career in Sri Lanka.

About me: My doctoral study aims to answer whether phosphate fertiliser driven soil fluorine has a detrimental effect on soil microorganisms. Part of my PhD work has addressed problems with conventional techniques of soil fluorine analysis by developing a simple sodium hydroxide extraction method for total soil F, and a standardised extractable method for bioavailable soil F. This work has been a contribution to ongoing environmental monitoring of soil fluorine in New Zealand soils and is being considered in the development of F environmental quality guideline values for New Zealand agricultural soils.

Alan Palmer thoroughly enjoyed explaining the pedology and soils on the "Productive Landscapes Field Trip" at the NZSSS conference in Napier, December 2018.

The Manaaki Whenua gamma soil survey system was demonstrated at the NZSSS Productive Plains field trip (Photo: Carolyn Hedley)

James Hanly received the 2018 America/New Zealand Soil Science Travel Award from Soil Science Society of America (SSSA), which was funded by the Agronomic Science Foundation. The award supported his attendance at the SSSA Annual Meeting, called *Soils Across the Latitudes*, in San Diego, January 6-9 2019, where he presented research titled *Nitrogen fertiliser strategies for increasing taro sucker production in Taveuni, Fiji* (R Lal, N Roskruge, J Hanly & J Millner). The travel award also provided the opportunity for James to visit the University of Hawaii at Mānoa, hosted by Prof Jonathan Deenik, Department of Tropical Plant and Soil Science, for two weeks in December 2018. During his visit he conducted research evaluating a modified Olsen P test, using Hawaiian soils. The test is intended for use by agricultural field officers in Pacific Island countries.

James Hanly and Jonathan Deenik at the SSSA Annual Meeting in San Diego

Canterbury

Scion (Rotorua/Christchurch)

Scion (Rotorua / Christchurch)

Given it is the sesquarcentennial for phosphorus, in this issue the Scion soil science team would like to share some of the past research performed with this critical element in New Zealand's planted forest estate.

Phosphorus application in Riverhead Forest

In the 1950's it became apparent that the radiata pine planted in Riverhead forest (established in the 1930's) were suffering from a significant phosphorus deficiency. This manifested as short, yellow-tipped needles in younger trees and narrow thin crowns in older trees.

Examples of phosphorus deficient radiata pine in Riverhead forest. Image sourced from Davis et al. (2015), Planted-forest nutrition.

This prompted a considerable research programme spanning several decades exploring the use of single superphosphate (SSP) fertiliser to resolve the issue. Minimal quantities of SSP (~ 25 kg P/ha) were insufficient to overcome P deficiency, larger quantities (~250 kg P/ha) proved successful and in the late 50's and early 60's aerial applications of about 50-60 kg P/ha were routinely conducted by forest managers.

Later trial work in the forest examined the specific rate requirements, exploring applications between 25 and 250 kg/ha as well as the effect of various timing of application of phosphorus. The findings showed applying 125 kg P/ha either as a single or split application, or 250 kg/ P/ha, resulted in essentially similar productivity of about 550 m3/ha.

In the early 90's, it was becoming increasingly apparent that the first series of phosphorus trials at Riverhead had outlived their usefulness, particularly in terms of demonstrating gross phosphorus deficiency. The trees were in excess of 60 years of age and well beyond the stage where phosphorus deficiency becomes noticeable in young plantations of radiata pine. The value of continuing the demonstration had become questionable. However, in consultation with Carter Holt Harvey Forests Ltd it was agreed that the location of the trials should be persevered as a "Museum" site. As such, the site was replanted in 1997 and managed outside of the normal forest procedure without phosphorous additions in order to provide a demonstration site to foresters. Over time, vast differences in performance developed between control plots and those that had received some level of phosphorous application in the past. The multi-hectare site is still maintained, and formed an important part of the 2016

“Growing Confidence in Forestry’s Future” field trip by providing a clear indication of the ongoing importance of phosphorus nutrition to forest productivity.

To this end, research into phosphorus availability and uptake in the New Zealand planted forest estate is still ongoing, with a large trial established recently in Tairua forest to explore options for maximising productivity on highly phosphorus retentive soils. Opportunities to boost forest growth through a better understanding of phosphorus in concert with other nutrient are also being explored through various trials designed to enhance productivity (as opposed to correcting deficiency). Lastly, the NuBalM platform has been augmented with a new module to estimate annual phosphorus demand and partitioning within the biomass of a developing stand if radiata pine. These current efforts are receiving strong support from the forestry sector, and will further enhance our knowledge around the functions and critical thresholds of these elements in our forest soils

Jeff Hatten joins Scion for a six month sabbatical

Jeff Hatten is an Associate Professor of forest soils in the Forest Engineering, Resources & Management Department at Oregon State University (OSU). He earned a B.Sc. degree in Environmental Science from Western Washington University and Ph.D. degree in Forest Resources from the University of Washington. After his formal education in forest soils he accepted a postdoctoral position with an organic geochemist in the College of Oceanic and Atmospheric Sciences at Oregon State University. Prior to joining OSU in 2012, he was an assistant professor in the Department of Forestry at Mississippi State University (MSU). He teaches courses in forest soils and forest nutrition. Jeff’s research focusses on forests soils and the source of sediment in managed settings that include intensively managed forests, prescribed fire, and other less intensively managed settings Jeff has actively participated in the Division of Forest Range and Wildland Soils of the Soil Science Society of America and is currently the outgoing chair for the division. Jeff will be working with the Scion soil science team on issues relating to the stability of soil carbon stocks in planted forests and the management of soil nutrition in radiata pine and Douglas-fir forests. Jeff will be based in Christchurch with his family for the majority of his stay in New Zealand.

Jeff hard at work in a soil pit located in H. J. Andrews Experimental Forest, Oregon.

Scion staff at the 2018 NZSSS Conference

Scion staff had a great time at the conference, and a range of good opportunities for collaboration were developed. We would like to extend our thanks to the organising committee for the effort they put into this event.

The Scion soils team (and friends) at the conference dinner, just after winning the quiz

Lincoln University

In late January Peter Almond joined a group of paleoseismologists from the University of Canterbury and GNS Science, led by Prof. Andy Nicol (UoC), investigating the earthquake history of faults that moved in the 2016 Kaikoura earthquake. Most faults moved evidence of movements prior to the 2016 event. The challenge now is to determine how many events and the characteristic displacements associated with past events. This kind of information is key to better assess earthquake hazard.

Prof Andy Nicol at a trench on the Charwell-Conway Fault

Research shows environmental benefits of effluent treatment system

New research conducted by Lincoln University on a farm dairy effluent (FDE) treatment system in Canterbury has shown the system could have significant environmental benefits for river, lake and groundwater quality.

Professor Keith Cameron and Professor Hong Di, of Lincoln University's Centre for Soil and Environmental Research, say field lysimeter trials have shown significant reductions in leaching losses of total phosphorus (TP), dissolved reactive phosphate (DRP) and E. coli from treated FDE applied to pasture soil when compared with losses from untreated FDE. You may like to view the latest ClearTech news video on The NZ Herald website.

Mix 'n Match in agriculture

On a cold and blustery summer day in Milton, Roger McLenaghen and Josh Nelson attended the first of the seven Young Farmer regional competitions. This is part of the Lincoln University sponsorship for the Young Farmers, Junior Young Farmer and AgriKids events. For both the Junior YF and the Agrkids competitions contestants are required to match agricultural products with their "preferred" soil that provides "Terroir".

The idea for this module came from Roger attending the NZSSS conference dinner in Napier last year, where dinner guests were asked to pick the soil that various wines are produced from. Roger's table failed, getting only one correct (he's knows much more about terroir now, and still drinks wine).

Some of the products and soil matches used in the competition are:

Esk Valley wine	Gimblett gravel soil
Whitestone cheese	Limestone soil

Taupo beef	Pumice soil
Merino wool	Central Otago schist soil
Bailey Beauty potatoes	Sandy soil from Kaitorete Spit

Staff and Postgrad Students activities

New Zealand Soil Science Society Conference, Napier, December 2018

A large contingent of staff and students from the Soil and Physical Sciences Department attended the Conference in Napier. The conference was a great opportunity for our postgraduate students to present their research as talks or posters. Two of our postgraduates won awards: Kirstin Deuss winning the T. W Walker prize for the best student poster award and Monica Giona Bucci being awarded the Morice Fieldes Award for best PhD thesis. The TW Walker prize was named after Prof Walker, the inaugural chair of Soil Science at Lincoln.

Kirstin Deuss with her supervisor Peter Almond

6th National Australian Soil Judging Competition

Prior to the conference, the Second NZ Soil Judging Competition was held at Matapiro Station with teams from Lincoln, Massey and Waikato. Lincoln came 2nd in the team competition (Waikato first) and in the individual competition, Julie Gillespie won, with Kirstin Deuss 3rd. Julie was also part of the soil judging team who recently took part in the Australian National Soil Judging Competition; she is studying Hons in the Dept. this year. Well done to everyone involved.

Team Lincoln in the soil judging competition (allophanic Brown soil). L to R: Louisa Hall, William Talbot, Julie Gillespie, Kirstin Deuss.

From left front row: Chris Chisholm, Hamish Dunbar, Jack Dixon, Jennifer Tregurtha, Lucy Bell, Emma Chrystall, Hannah Vaughan, Fiona Anderson, Dr Carol Smith, Roger McLenaghen, Dr Janet Bertram, Assoc Prof Jim Moir, Judith Van Dijk, Dr Nik Lehto, Josh Nelson, Dr Henry Chau, Prof Tim Clough. Absent: Louise Schwass, Penny Chapman and Rachel Wood.

Soil Science Prize Giving: Prizes are awarded each year to the top 3 students in Soil Science at each level of study at Lincoln University. The 2019 awards were presented on Wednesday 20th February. The prizes are awarded by the Centre for

Soil & Environmental Research in recognition of excellence and to encourage top students to continue their high level of performance in Soil Science. The prize winners receive a Certificate and book tokens. Many of the previous prize winners have gone onto study for a post-graduate degree in Soil Science leading to careers in industry, farming, CRIs, regional councils, universities and government ministries.

Plant & Food

Lucy McLean has started as a field research associate in the Field Operations team.
Dirk Wallace has conferred his PhD thesis on “Amendment incorporation to increase soil water retention”. Congratulations Dirk!
Denis Curtin was conferred as a Fellow of the New Zealand Society of Soil Science at the Society's biennial conference in December 2018. The award was in recognition of his substantial contributions to research on soil organic matter and soil fertility over a long and distinguished career.

Mike Beare was invited by the Soil and Water Management and Conservation Division of Soil Science Society of America to give a keynote presentation to a symposium entitled: Anthropogenic and climate-induced soil change: A transdisciplinary overview at the International Soil Science Meeting which was held on January 6-9, 2019 in San Diego, CA.

The work on dairy grazed forages has finished with some interesting results. Our recent research has shown that the use of no-tillage (direct drill) practices to establish forage crops like fodder beet and kale can markedly reduce the soil compaction that results for livestock treading during winter grazing. This lower compaction helps to reduce the emissions of nitrous oxide to the atmosphere and to improve the performance of subsequent crops. Although no-till crops can have more variable dry matter production, our recent results indicate that similar or higher yields can be achieved at a lower total cost of crop production. These findings are attracting considerable interest among farmers and industry experts in both the arable and pastoral sectors. Consequently, increasing adoption of no-till practices for forage crop production is helping farmers to reduce their environmental footprint and improve the profitability of forage cropping systems. The project is co-funded by the MBIE *Forages for Reduced Nitrate Leaching* Programme in partnership with DairyNZ, FAR, AgResearch, Manaaki Whenua Landcare Research, and Lincoln University.

The trial site shown being grazed by dairy cows in June 2018

Steve Thomas, Dirk Wallace, Steph Langer and others has been busy in the PFR lysimeter facility recently on a project investigating smarter methods top apply nitrogen and water to reduce environmental impacts. They are testing irrigation and fertigation intensities and methods of application on shallow stony soils in intact lysimeters using spray and drip irrigation with a range of intensities from 2 – 22 mm/h. The work is investigating the effects on N leaching drainage and N_2O gas emissions.

Gas emission measurements completed at the lysimeter facility (L to R) Dirk Wallace, Steph Langer and Steve Thomas

Steven Dellow continues his work on the "Nitrogen – measure it, manage it" using quick test nitrate strips for more efficient nitrogen application to crops including potatoes, maize, leafy greens and intensive vegetable production. This work was presented to a Potatoes NZ field walk at Southbridge, where a number of Australian vegetable growers were in attendance. Steve's work on the Nitrogen manager was well received.

Related Society Notices

Land Monitoring Forum

The LMF held their biannual meeting in September 2018. National initiatives regarding soil quality monitoring were an important topic. Funding for a NEMS for soil quality has been secured and a working group will continue this work in April. There were technical presentations relating to soil quality including Soil biological indicators for forestry and Soil carbon and nitrogen indicators.

The afternoon sessions were set aside for a workshop on versatile land & high class soils. Urban expansion is worldwide and there is a great need for land management planning. Results can be Land fragmentation and over allocation of water. Tension between different NPSs were identified. Many questions:

- How do we obtain a landscape that is more resilient, robust & productive?
- How is sustainable farming to be rewarded?
- What are the barriers to sustainable farming?
- What is high class soil?
- Does it matter if we lose high class soils? Can the urban environment provide its own food security?

Responses include obtain robust evidence to fill information gaps and set priories:

- Better LUC definition with a long-term timeframe. Conflicting policies hinder
- Better identify what supports land use & the impacts of these activities on the environment
- Bring together water security + food security + integrating land suitability.
- Avoid adverse outcomes. Better define what is the measure of High class soils
- What values do we find in soils? Would local solutions be better?
- There is limited capacity in councils to do all required
- Recognition of the land fragmentation issue. Map what it will look like in 30 years
- Other factors as well as soils for food. Need values.
- Trade-off of ecosystem services need applied values.
- Preserve soil diversity.
- Lessons from Europe (Spain - Hectares of glasshouses).

Several reports were received the following day including erosion management (MfE), which mainly was applicable to pastoral farms, updates from EMaR, LUCCs RMG, SMAP and LCDB. In addition, each region gave an update on current activities and urgent issues. Some items that might be of interest:

- Urban forest vegetation study - what is happening to the trees?
- Where to put 1billion trees?

- Localised flooding events mobilising forestry slash
- What to do with 70000 t of grape skins?
- WRC undertook 5-yearly riparian survey for the fourth time

A very busy and full on meeting as usual. Already the next meeting is not far away (7- 8th March 2019)

International Union of Soil Sciences

From the desk of Rattan Lal President, International Union of Soil Sciences:

Viewpoint "Subject: Soil Pollution "
http://iuss.boku.ac.at/files/soil_pollution_12012018.pdf

Viewpoint "Subject: Making Soils of Agro-ecosystems Emission Negative"
http://iuss.boku.ac.at/files/iuss_12262018_special.pdf

The Dirt: Unearthed

Recently, this advert was spotted in the Spotlight circular:

How much would you pay for a bag of “Play dirt” and what would you do with it?

Recent publications and abstracts

Calvelo Pereira R, Camps Arbestain M, Kelliher FM, Theng BKG, McNally SR, Macias F, Guitian F 2018. Assessing the pore structure and surface area of allophane-rich and non-allophanic topsoils by supercritical drying and chemical treatment. *Geoderma*, 337: 805-811, DOI:10.1016/j.geoderma.2018.10.037.

Chamindu Deepagoda TKK, Clough TJ, Thomas SM, Balaine N, Elberling B 2018. Density Effects on Soil-Water Characteristics, Soil-Gas Diffusivity, and Emissions of N_2O and N_2 from a Re-packed Pasture Soil. *Soil Science Society America Journal*. doi:10.2136/sssaj2018.01.0048

Curtin D, Beare MH, Qiu WW, Tregurtha CS 2019. Nitrogen cycling in soil under grass-clover pasture: Influence of long-term inputs of superphosphate on N mineralisation. *Soil Biology and Biochemistry* 130:132-140. https://doi.org/10.1016/j.soilbio.2018.12.003.

Curtin D, Beare MH, Qiu WW, Sharp J 2019. Does Particulate Organic Matter (POM) Meet Criteria for a Model Soil Organic Matter Pool? *Pedosphere.*

Kirschbaum MUF, Giltrap DL, McNally SR, Liáng LL, Hedley CB, Moinet GYK, Blaschek M, Beare MH, Theng BKG 2018. Estimating the surface area of soils from their moisture factors. How to adjust for the water adsorption by soil organic carbon? *European Journal of Soil Science* (Submitted).

Lian, H.S., Lei, Q.L., Zhang, X.Y., Haw, Y., Wang, H.Y., Zhai, L.M., Liu, H.B., Jr-Chuan, H., Ren, T.Z., Zhou, J.G., Qiu, W.W., 2018. Effects of anthropogenic activities on long-term changes of nitrogen budget in a plain river network region: A case study in the Taihu Basin. *Science of the Total Environment*. 645, 1212-1220.

Lin, L.N., Li, Z.Y., Liu, X.W., Qiu, W.W., Song, Z.G., 2019. Effects of Fe-Mn modified biochar composite treatment on the properties of As-polluted paddy soil. *Environmental Pollution.* 244, 600-607.

Liu, X.W., Zhang, G.G., Lin, L., Khan, Z.H., Qiu, W.W., Song, Z.G., 2018. Synthesis and Characterization of Novel Fe-Mn-Ce Ternary Oxide–Biochar Composites as Highly Efficient Adsorbents for As(III) Removal from Aqueous Solutions. *Materials. 11*(12), 2445. https://doi.org/10.3390/ma11122445.

Lin, L., Zhang, G.G., Liu, X.W., Khan, Z.H., Qiu, W.W., Song, Z.G., 2019. Synthesis and adsorption of Fe-Mn-La-impregnated biochar composite as an adsorbent for As(III) removal from aqueous solutions. *Environmental Pollution*. https://doi.org/10.1016/j.envpol.2019.01.044.

Schiedung M, Beare MH, Tregurtha C, Don A, Thomas S. 2018. Deep soil flipping increases carbon stocks of New Zealand grasslands. *Global Change Biology* (Submitted)

Shen Q, Camps Arbestain M, McNally S, Calvelo Pereira R 2018. An investigation of organic matter quality and quantity in acid soils as influenced by soil type and land use. *Geoderma*, 328 (15), DOI: 10.1016/j.geoderma.2018.05.006.

Thomas SM, Fraser PM, Hu W, Clough TJ, van der Klei G, Wilson S, Tregurtha R, Baird D 2019. Tillage, compaction and wetting effects on NO_3, N_2O and N_2 losses. Soil Research (In press).

Vujinović T, Clough TJ, Curtin D, Meenken ED, Lehto N, Beare MH 2018. Quantity and biodegradability of dissolved organic matter released from sequentially leached soils, as influenced by the extent of soil drying prior to rewetting. *Soil Research* (Submitted).

Xu, Y.B., Qiu, W.W., Sun, J.P., Muiller, C., Lei, B.K., 2018 Effects of wheat/faba bean intercropping on soil nitrogen transformation processes. *Journal of Soils and Sediments*. https://Doi.org/10.1007/s11368-018-2164-3.

Yang, T., Li, D.D., Clothier, B., Wang, Y., Duan, J., Di, N., Li, G. D., Li, X., Jia, L. M., Xi, B. Y., Hu, W., 2019. Where to monitor the soil-water potential for scheduling drip irrigation in Populus tomentosa plantations located on the North China Plain? *Forest Ecology and Management* (In press).

Yi, J., Yang, Y., Lou, S.L., Zhang, H.L., Liu, M.X., Hu, W., 2018. Visualization of macropore features and preferential flow on a mountain forest soil under different level human disturbances with combination of computed tomography and breakthrough curve. *Soil Research* (Submitted).

Zhao, Y., Ding, D.Y., Si, B.C., Zhang, Z.H., Hu, W., Schoenau, J., 2019. Temporal variability of water footprint for cereal production and its controls in Saskatchewan, Canada. *Science of the Total Environment*. Doi, https://doi.org/10.1016/j.scitotenv.2018.12.410.

Beare MH, Curtin D, McNally S, Thomas S, Lawrence-Smith E, Tregurtha , Hu W 2019. Soil, Land-Use & Climate Change Impacts & Mitigation in New Zealand. Presentation to a cross-divisional symposium entitled: *Anthropogenic and climate-induced soil change: A transdisciplinary Overview*. International Soils Conference, San Diego, CA, 7 January 2019.

Frampton R, Wright P, Anderson C, Falloon R 2018. The microbiome of soils suppressive to *Spongospora* diseases of potato. ICPP2018, 29th June – 4th August, Boston, USA.

Peterson M, Anderson C, Fraser P, Joyce N, Curtin D 2018. Do plant secondary metabolites excreted in sheep urine influence soil microbial community structure and function? ISME 2018, 13th to 17th August, Leipzig, Germany.

Beare MH, Curtin D, McNally S, Thomas S, Lawrence-Smith E, Tregurtha , Hu W 2019. Soil, Land-Use & Climate Change Impacts & Mitigation in New Zealand. Presentation to a cross-divisional symposium entitled: *Anthropogenic and climate-induced soil change: A transdisciplinary Overview*. International Soils Conference, San Diego, CA, 7 January 2019.

Frampton R, Wright P, Anderson C, Falloon R 2018. The microbiome of soils suppressive to *Spongospora* diseases of potato. ICPP2018, 29th June – 4th August, Boston, USA.

Peterson M, Anderson C, Fraser P, Joyce N, Curtin D 2018. Do plant secondary metabolites excreted in sheep urine influence soil microbial community structure and function? ISME 2018, 13th to 17th August, Leipzig, Germany.

Effect of forage crop establishment on dissolved organic carbon dynamics and leaching in a hill country soil

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Soil Use and Management **https://doi.org/10.1111/sum.12497**

Abstract

Intensive agricultural activities could affect the dynamics and leaching of dissolved organic carbon (DOC) and nitrate from agricultural soils to receiving waters. This study investigated soil DOC dynamics immediately (0-12 days) after spraying a hill country perennial pasture with agrochemicals to establish a winter forage crop for supplementary feed production. Two treatments were examined – perennial pasture (without agrochemicals) and swede (*Brassica napobrassica* Mill.) cropping (after spraying with agrochemicals), both growing on a Typic Eutrudept. Soil samples were collected from various depths down to 1 m, before the application of agrochemicals (day 0) and 1, 6 and 12 days thereafter. DOC concentration below the surface soil (< 5 cm) was generally not altered by the agrochemicals. This was further proved by the isotopic monitoring of DOC leaching on this soil. Conversely, the agrochemicals significantly (p = 0.03) increased DOC concentration within the 0-5 cm soil depth on day 1, due to the direct contribution of organic molecules and/or displacement of organic compounds at adsorption sites by the agrochemicals; and on day 6, due to root necromass decomposition. The increase of nitrate in soil solution at this depth (0-5 cm) on days 6 and 12 suggests that the agrochemicals may have also enhanced nitrogen (N) mineralisation in the surface soil. However, the significantly (p = 0.04) higher DOC/nitrate (molar ratio) of the agrochemical treatment suggests that the agrochemicals used for clearing out pasture before forage crop establishment could lead to a short-term increase in surface soil denitrification.

A critical review on bioremediation technologies for Cr(VI)-contaminated soils and wastewater

Shaopan Xia[a], Zhaoliang Song[a], Paramsothy Jeyakumar[b], Sabry M. Shaheen[c,d], Jorg Rinklebe[d,e], Yong Sik Ok[f], Nanthi Bolan[g], and Hailong Wang[h,i]

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[i]School of Environment and Chemical Engineering, Foshan University, China

Abstract: Chromium (Cr) is a potentially toxic metal originating from natural processes and anthropogenic activities such as the iron- steel, electroplating, and leather industries, which is carcinogen to living organisms and has an ecological risk. Hence, research into the remediation of Cr pollution has attracted widespread attention. Bioremediation techniques have advantages of causing little disturbance to soil and water, low cost, simple and convenient operation, and less secondary pollution. In this review, we briefly describe the chemical properties of Cr, sources of Cr pollution, environmental quality, toxicological/health effects of Cr, and analytical methods. We also discuss the factors that govern methods for the

bioremediation of Cr and compare their advantages and disadvantages. In particular, we focus on efforts to establish Cr bioremediation processes and their mechanisms. The main mechanisms include biosorption, bioaccumulation, complexation, electrostatic attraction, Cr(VI) reduction to Cr(III), and ion exchange, which decrease the Cr(VI) concentrations and convert Cr(VI) into Cr(III) lowering its toxicity and making it environmentally benign. However, bio- remediation is still a challenging technique and most studies remain at the laboratory stage. Therefore we suggest areas for future research and provide theoretical guidance and a scientific basis for the application of biosorbents for Cr(VI) bio- remediation in soils and wastewater.

Shaopan Xia, Zhaoliang Song, Paramsothy Jeyakumar, Sabry M. Shaheen, Jörg Rinklebe, Yong Sik Ok, Nanthi Bolan & Hailong Wang (2019): A critical review on bioremediation technologies for Cr(VI)-contaminated soils and wastewater, *Critical Reviews in Environmental Science and Technology*. https://doi.org/10.1080/10643389.2018.1564526

Organic carbon content controls the severity of water repellency and the critical moisture level across New Zealand pasture soils

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Organic matter can render soil hydrophobic and cause soil water repellency (SWR) which has large implications for agriculture. Consequences such as fingered flow, uneven wetting patterns, and increased overland flow reduce irrigation efficiency and plant nutrient availability. The phenomenon of SWR is a transient soil property depending, inter alia, on soil water content (w). Soil can exhibit SWR from oven-dry w until the critical w where it again becomes fully wettable (wNON). The total SWR can be obtained from the nonlinear SWR-w relationship as the integrated trapezoidal area under the SWR-w curve (SWRAREA). We analyzed 78 soil samples, representing five dominant soil orders in the South Island of New Zealand. The soils had a large range in clay (0.000–0.520 kg kg^{-1}) and organic carbon (OC) content (0.021–0.217 kg kg^{-1}). The degree of SWR was measured on soils at air-dry conditions (SWRAD) and after heat-pretreatment at 60 (SWR60) and 105°C (SWR105). Further, SWR was measured in small w increments above air-dry w until wNON was reached. The SWR-w curves were either unimodal or bimodal, or no SWR occurred. SWRAREA ranged from 0.16 to 26.82 mN m^{-1} kg kg^{-1}. Among the five soil orders tested, the Podzols exhibited the highest severity in SWR, whereas the Semiarid soils were the least hydrophobic soils. In conclusion, OC was the main factor for controlling the severity of SWR. Though, pH also had minor effects on SWR. Further, an upper limit critical water content was derived from the simple relationship between the wNON and OC, which could be applied to improve irrigation

practices of pastoral soils. However, there is a need for further testing on different soils and land uses.

Hermansen, C., Moldrup, P., Müller, K., Jensen, PW., van den Dijssel, C., Jeyakumar, P., de Jonge, LW. (2019). Organic carbon content controls the severity of water repellency and the critical moisture level across New Zealand pasture soils. *Geoderma*. 338, 281-290. https://doi.org/10.1016/j.geoderma.2018.12.007

Conferences and Training

The General Assembly 2019 of the European Geosciences Union (EGU):

Soils as a non-point source of contamination by emerging contaminants, including pesticides or their degradation products

7-12 April 2019, Vienna, Austria,
The scientific session "**Soils as a non-point source of contamination by pesticides or their degradation products**" will provide an opportunity to research teams working in different parts of the world to discuss their findings within the settings of a large conference. SSS8.5/BG2.67/HS8.3.15
https://meetingorganizer.copernicus.org/EGU2019/session/31533

Wageningen Soil Conference: Understanding soil functions

27-30th August 2019, Wageningen, Netherlands
Wageningen University & Research is delighted to invite you to join us at the fourth edition of the Wageningen Soil Conference. As in previous editions, the aim is to discuss the importance of soils. In the 2019 edition, the focus will be on "Understanding soil functions: from ped to planet". To do this we will adopt a new style of conference, with traditional conference talks in the mornings, followed by a range of scientific and interactive topic masterclasses in the afternoons. Abstracts due **15 April 2019.**
https://wageningensoilconference.eu/2019/

International Interdisciplinary Conference on Land Use and Water Quality' – Agriculture and the Environment

3-6 June 2019, Aarhus, Denmark
LuWQ2019 is conference on the cutting edge of science, management and policy to minimise effects of agriculture and land use changes on the quality of groundwater and surface waters. The conference is aimed at scientists, land and water managers and policy makers involved in water quality improvement. If you consider attending and would like to have a conversation with a local member of the Scientific Advisory Committee, please feel free to contact Roland.Stenger@lincolnagritech.co.nz.
More information: www.luwq2019.dk

7th International Symposium on Soil Organic Matter: Soil Organic Matter in a Stressed World

6 – 11 October 2019, Adelaide, South Australia
It is of course this amorphous substance, SOM, that draws our interests together and affords us the privilege to invite you to the wonderful city of Adelaide, South Australia, where the 7th iteration of the International SOM Symposium Series will be held from 6th -11th October 2019. The conference follows the amazingly successful editions at Rothamsted Research, UK (2017), Georg-August-Universität Göttingen, Germany (2015), and their four predecessors stretching back to the initiation of the series at Potiers, France, in 2007. It draws together a vibrant mix of established world experts, early and mid-career researchers, and students in order to share knowledge, make new connections, and advance the field of SOM research.
More information: www.som2019.org

New Zealand Trace Elements Group (NZTEG) Conference 2019

POSTPONED – NEW DATE TO BE ADVISED, University of Waikato, Hamilton
The scientific programme will include all aspects of the science of trace elements. Topics include (but are not restricted to) trace element related aspects of the following areas: Speciation analysis; Monitoring and forensics; Environmental chemistry; Industry, technology, agriculture; Isotope tracers; Toxicology and health. please email amanda.french@waikato.ac.nz

Foodomics 2019

9 - 11 April 2019, Auckland
For New Zealand researchers and businesses taking premium foods for health and wellbeing to the world gather to collaborate, learn about the latest research and opportunities and network.
More information: https://www.highvaluenutrition.co.nz/2018/06/26/foodomics-2019/

Crazy & Ambitious 2 - New Zealand's Biological Heritage National Science Challenge:

20 - 21 May 2019, Wellington
Panel discussions, live Q&As, keynote speakers and quick-fire updates on the science and research being done across 18 National Science Challenge parties.
More information: https://royalsociety.org.nz/events/crazy-and-ambitious-2-new-zealands-biological-heritage-national-science-challenge/

Solute Imaging Summer School 2019: High-resolution chemical imaging of solutes in soils and sediments

12 – 17 September, 2019, Vienna, Austria
This Summer School consists of several parts, combining e-learning content, theoretical lectures about the techniques, practical lab work in the form of mini-projects and a final presentation of the lab results. The course aims on training

applicants at a postgraduate level (PhD students) and young researchers. The applicants are selected based on their motivation letter, where they are required to highlight their research interest and potential application of solute imaging techniques to their current research project. Application deadline: 1 March 2019
For more information: https://dgt2019.boku.ac.at/soluteimaging/

Early announcement – save the date

WAI-BOP Soils Biennial Conference 2019 – "Commemorating Mendeleev"

Friday 29 November 2019, University of Waikato, Hamilton

We will hold the 5th biennial regional conference at the University of Waikato, Hamilton, on Friday 29th November this year (a little earlier than normal because of other conference commitments).

The meeting will feature members and students mainly from the Waikato-Bay of Plenty regions but soil scientists and associated supporters from elsewhere are welcome to contribute or participate and to enjoy an informative and friendly day talking and thinking about our favourite topic (no, not Rugby World Cup, soils). This year's N.H. Taylor Memorial Lecture will be presented as part of the conference. The only criterion to take part in WAI-BOP SOILS is that you must be a signed-up (paid) member, or student member, of NZSSS. More details about the conference will be available later in the year.

Special commemoration for the 5th WAI-BOP SOILS 2019 meeting:

Painting of Dmitri I. Mendeleev (1834-1907)
by Ivor Kramskoi, 1878 (from Giunta, 2017)

Commemorating Mendeleev and his Pioneering Roles in Pedology (143 yr ago) and Periodicity (150 yr ago)

David Lowe and Anne Wecking (convenors) *(all correspondence to david.lowe@waikato.ac.nz)*
School of Science (Earth Sciences), University of Waikato, Hamilton

Opportunities and Awards

New Zealand Society of Soil Science Awards 2019

Nominations for the following awards open 1 March 2019 (with the exception of the US/NZ Exchange Award, for which nominations open 25 January). Key details regarding nomination requirements are provided in the table below. Please contact the NZSSS Awards Convenor for full award details (Brendon.Malcolm@plantandfood.co.nz).

Award	Presented	Nominations close	Nominee eligibility	Nominator eligibility
NZSSS Fellowship	Annually	31 July 2019	Nominees must be active members of the Society at the time of nomination.	Nominations must be made by two Full Members, or Life Members of the Society.
The Grange Medal	Biennially (conference year)	31 July 2020	Open to both non-members of the Society as well as members, fellows, or life members of the NZSSS.	Nominations must be made by two or more active members of the Society.
The Blakemore Award	Biennially (conference year)	31 July 2020	Open to technicians/support staff who have been employed in the field of science for at least three years.	Any two active members of the NZSSS can nominate an eligible candidate from a university, CRI, or other organisation (e.g. a Regional Council).
The Leamy Award	Biennially (conference year)	31 July 2020	Open to the author or authors of the most meritorious New Zealand contribution to soil science, published in the previous three calendar years.	Any two active members of the NZSSS can nominate an eligible candidate(s) from a university, CRI, or other organisation (e.g. a Regional Council).
The Quin Award	Annually	31 July 2019	Open to postgraduate (PhD)	Nominations must be received in writing from

			students in soil science about to enter their third year of study. Candidates must be either student or full members of the NZSSS and should not be on the academic or technical staff of the department that nominates them.	the Head of the Soil or Earth Science Department/Group at a New Zealand University. Only one nomination will be accepted from each University Department/Group.
The Fieldes Award	Annually	31 July 2019	A PhD thesis submitted within the previous calendar year.	The Head of the Soil or Earth Science Department/Group at a New Zealand University may nominate the best PhD thesis from their department/group.
The Rigg Award	Annually	31 July 2019	A Masterate thesis submitted within the previous calendar year.	The Head of the Soil or Earth Science Department/Group at a New Zealand University may nominate the best Masterate thesis from their department/group.
Undergraduate Prizes	Annually	31 December 2019	A third-year student in Soil or Earth Sciences.	The Head of the Soil or Earth Science Department/Group at Massey, Lincoln, and Waikato University may each nominate the best third-year student from their department/group.
The US/NZ Exchange Award	Annually	15 April 2019 for initial submission (18 April for final submission)	Nominees are required to have at least seven years of membership in SSSA or the NZSSS. Former recipients of this Award are not eligible.	This award allows self-nominations.

Nominations and requests for further information regarding NZSSS awards should be addressed to:

Dr Brendon Malcolm
NZSSS Awards Convenor
C/O Plant and Food Research
Private Bag 4704, Christchurch Mail Centre, Christchurch 8140 (normal post), or

Canterbury Agriculture & Science Centre, Gerald St, Lincoln 7608 (courier)
New Zealand

Email: Brendon.Malcolm@plantandfood.co.nz

Postdoctoral Fellow - Soil Microbiology

In this role, you will be a member of the Bio-protection Research Centre (https://bioprotection.org.nz/) and will contribute to the research activity in soil microbiology, primarily investigating environmental conditions that influence the survival and virulence of soil and plant pathogens in New Zealand landscapes. The Centre is both a National Centre of Research Excellence (CoRE) with 7 partner institutes across New Zealand and a research-intensive quasi-faculty based by Lincoln University.
http://jobs.jobvite.com/lincolnuniversity/job/ogun9fw0

Nominations for Companion of Royal Society Te Apārangi:

Potential Companions are nominated by at least two (and up to five) Members of Royal Society Te Apārangi for people that meet the criteria. Nominations are due by the end of March each year. Nominations are considered by the Academy Executive Committee who make recommendations to the Royal Society Te Apārangi about who should receive the award of Companion. The call for nominations for Companions is open **until 29 March**.
https://royalsociety.org.nz/who-we-are/our-people/our-companions/how-companions-are-awarded/

Call for Royal Society Te Apārangi Medals and Awards:

There are a number of medals and awards are being offered in 2019 by Royal Society Te Apārangi. SEe this page for more details:
https://royalsociety.org.nz/what-we-do/medals-and-awards/medals-and-awards-news/2019-medals-and-awards/
The call for nominations is open with a closing date of **29 March**.

Charles Fleming Award for Environmental Achievement

For those who have achieved distinction in the protection, maintenance, management, improvement or understanding of the environment, in particular the sustainable management of the New Zealand environment.
https://royalsociety.org.nz/what-we-do/funds-and-opportunities/charles-fleming-fund/charles-fleming-award-for-environmental-achievement/
Closing date 30 June.

LabCitoyen

If you are 20-26 years old, speak French and are involved in promoting women's rights and gender equality, you could win a trip to represent New Zealand at LabCitoyen 2019 in Paris this July 2019!
https://nz.ambafrance.org/Call-for-application-open-LabCitoyen-2019
Closing date: 31 March 2019

FAST! Awards

Vincent Salomon Travel Award
This newly created award will support attendance of New Zealand students and early career researchers at a science related conference in France. Two scholarships will be awarded, each supporting expenses up to $2000. More information here: http://www.francenzst.org/what-we-do/vincent-salomon-fast-travel-award/

Student Conference Award
The 2019 FAST! Student Conference Award will support expenses of a tertiairy student involved in a collaborative project between New Zealand and France to attend a science related conference in New Zealand. Four scholarships will be awarded to support expenses up to $600. More information here: http://www.francenzst.org/what-we-do/fast-conference-award/
Closing date: 31 March 2019

Special Feature: Soil Mapping Protocols and Guidelines

Implications of the recent New Zealand Soil Mapping Protocols and Guidelines

Peter Singleton. Natural Knowledge Ltd, Hamilton.
25/1/19

Summary

In December 2018 the New Zealand Soil Mapping Protocols and Guidelines (2017) were released. These are a set of soil mapping requirements that specify protocols such as observation density and data recording. I believe the guidelines implications are significant for soil mappers and for councils. Some implications I agree with, others I don't.

Implications:

1. Guidelines become rules
2. Guidelines become the standard mapping protocol
3. To comply, S-map will need to be reduced to a less detailed 1:50,000 scale and cannot be used for Overseer or Dairy Effluent Irrigation Risk at the present farm scale
4. Many new farm-scale soil maps will require more observations
5. Increased accountability and legal exposure
6. Taxpayer, ratepayer and client costs will increase and pedologist knowledge is not used.

I agree with guidelines becoming rules for regional councils. This gives certainty and standardisation across agencies and consultants.

The guidelines show S-map is not appropriate at the scale of 1:10,000 that is used on-line. This means it must immediately be presented at a coarser scale to reflect its low observation density (maybe 1:50,000 to 1:100,000). Using S-map for farm-scale

Overseer and Dairy Effluent Risk is inappropriate given the lack of data points. Its use for these purposes needs to end immediately and farmers notified. Not to do so could leave councils and Landcare Research legally exposed.

The guidelines require collection of some data that is not relevant to many clients' needs. This includes the number of observations and types of measurements. Clients being required to pay for unnecessary data for council (and possibly Landcare Research's) databases is a form of targeted rate.

Regional S-mapping, and many farm soil maps, will require the public or clients to spend more money for the maps to be up to guideline standards. These costs are significant and for some councils will be $1M or more.

I consider aspects of observation density in the guidelines are incorrect and need to be revisited. Cost and benefit has not been carefully considered by the guidelines. In some cases, they are requiring significant effort for little or no gain. Theory and practice need to come closer together and produce a more pragmatic outcome that acknowledges the mapping skills of experienced pedologists who can reduce costs without reducing quality. The guidelines are too prescriptive and do not differentiate adequately between experienced and inexperienced mappers and do not give credit to the significant gains in efficiency and cost-saving that come from applying soil-landscape models. These omissions are harmful for soil science.

Background

The New Zealand Soil Mapping Protocols and Guidelines (Grealish, G. 2017) were made public on the Evirolionk site[1] in early December 2018. The report was guided by a Technical Advisory Group consisting of Regional Council and Landcare Research staff. The project was funded by Envirolink.

The protocols and guidelines aim '*is to help New Zealand implement a nationally consistent approach to conduct soil mapping.*' They cover a range of mapping scales from detailed to coarse.

Below I outline what I believe are important implications from the guidelines report. Some positive, and others that need to be addressed.

Implications

Implication 1: Guidelines become rules

Although the report is 'Guidelines', the intent is that they are the protocols to be used for mapping soils. Therefore, I'm unconvinced by the statement in the report that *'The protocol document is not intended to provide instruction on how to construct a soil map.'* The entire document is about exactly that. In describing the need for the protocols the report states *'National standards provide clarity and certainty to those investing in farm-scale soil information.*' So the intent is that these are the National Standards for soil mapping.

My experience is that guidelines used by councils can be used in a prescriptive way and are applied as rules. There is no room for discretion or professional judgement. If the 'guideline' procedures are not followed, then the soil map is sub-standard and

not fit for purpose. Words in the report like 'mandatory', and a 'checklist table' (ideal for compliance assessment) reinforce this (Table 3 of the guidelines lists mandatory requirements). The regional council dominance on the Technical Advisory Group confirms it. For example, the MFE Soil Contaminant Guidelines have essentially become rules for councils and professional judgement (although the intent of the guidelines) has been removed.

I am not against guidelines becoming rules. In the council environment it is necessary, and I agree with the approach. Those assessing the soil report in council are not soil mappers and need the security provided by a prescriptive approach. However, when guidelines are applied for regulatory purposes (such as for subdivision, nutrient budgeting or dairy shed effluent irrigation) they are no longer guidelines. They have then become minimum mandatory requirements. Failure to comply means the soil map is sub-standard and should be rejected.

Implication 2: Guidelines become the standard mapping protocol

The intended regulatory use of the Guidelines, and their status as the New Zealand Standard means they will be the method for mapping soil. Any professional must use them or risk accusations of sub-standard work and clients questioning why standard practice was not followed. There is also the risk that the clients soil report could be rejected by council. Professionals use standard procedures. Not using the New Zealand Soil Mapping Protocols and Guidelines for mapping would be a high risk.

The advantage is that the Guidelines produce an equitable level of expectation. Double standards can't exist, and agencies and council soil maps would be bound by the same standards expected of consultants.

I agree with standardised mapping protocols for councils, research agencies and consultants.

Implication 3: S-map is at the wrong scale and incorrect for farm-scale Overseer and Dairy Effluent Irrigation Risk mapping

If a soil map is used for diary effluent irrigation risk assessment or Overseer, then the guidelines require a medium density of observations (1 observation for every 2 cm^2 of map). The number of observations for various scales is shown in Table 1 below.

Table 1. Map scales and number of observations for medium density (1 every 2 cm^2 of map) site observations.

Map scale	cm^2 of map per 100 ha	Observations needed for 100 ha
1:5,000	400	200
1:8,000	169	85
1:10,000	100	50
1:15,000	49	25
1:50,000	4	2
1:100,000	1	0.5

Online S-map has a default detailed scale of 1:10,000 (1:10,000 is a farm-scale map). S-map is used by councils and Landcare Research as the basis for maps showing farm-scale dairy effluent irrigation risk and Overseer nutrient budgeting (often as a regulatory tool). The protocols require a medium density of observations (1 per 2 cm^2 of map). At least 50 observations are, therefore, required for the average 100 ha Waikato dairy farm. Observations are not computer-generated prediction points, the guidelines state at least 75 % are auger, pit and cuttings. So that means 38 physical soil observations per 100 ha. Of these, at least 10 % must be detailed morphological descriptions (e.g. soil pits). The remaining 25 % are field based visual clues that help mapping e.g. vegetation change (Table 7 of the guidelines).

S-map has not collected 50 observations for every 100-ha farm as required for 1;10,000 mapping. In most cases the number of observations on a farm is likely to be zero. S-map has recently been completed for the Waipa catchment in the Waikato, and for Hawke's Bay. Applying the guidelines requires Landcare to have collected the number of observations listed in Table 2 which is 1 observation per 2 cm^2 of map. I do not know the observation density for these two maps, but it is much less than required for 1:10,000 scale. The appropriate scale for S-map is more likely to be 1:50,000 and 1:100,000. It is certainly not the current 1:10,000. No doubt the metadata will be completed as required by the guidelines and that information will soon be readily available.

Table 2. Number of observations needed for S-map at different map scales.

		Observations (1 per 2cm^2)		
Catchment	Area (ha)	1:10,000	1:50,000	1:100,000
Waipa	306,569	153,285	6,132	1,533
Hawke's Bay	1,420,000	710,000	28,400	7,100

Presenting S-map at the appropriate scale for the data and not using it for Overseer and Dairy Shed effluent irrigation risk mapping will help address many concerns that have been expressed about its inappropriate use at the farm-scale. The guidelines developed by the Technical Advisory Group confirm S-map is inappropriate at the present scale. For this reason, I support the guidelines. They will introduce a rigour and quality standard into soil mapping (and S-map in particular) which is causing many issues by providing misleading information. It will bring Landcare Research and councils up to an acceptable standard for presenting soil maps.

Many farm management and regulatory decisions are being made using S-map at the farm-scale. Most of these decisions are likely to be wrong because the maps are inaccurate for farm-scale management decisions. S-map must no longer be presented on-line at the 1:10,000 scale. Farmers should be notified of the error and informed that their effluent irrigation and nutrient budgeting planning based on S-map is likely to be based on inaccurate soil data.

I agree with aspects of the site density guidelines at coarser scales (1:10,000 or coarser) and these can eliminate inaccurate presentation of soil data at the wrong scale.

Implication 4: Many farm-scale soil maps do not comply

Applying the site density protocol means most farm mapping needs an average observation density (e.g. auger hole, pit or cutting) of one for every 2cm^2 of map. The number of observations varies depending on the size of the map produced in the report. For a 100 ha dairy farm (the average Waikato dairy farm is 123 ha) a map size that is readable on an A4 page is about 170 cm^2 (1:8,000 scale). You can go bigger, but 1:10,000 to 1:8,000 seems to work. Table 1 shows that a 100 ha farm requires 50 to 85 observations depending on final map scale.

In some cases, this observation density is more or less than would usually be required. The complexity of the soil pattern and landscape does control the number of observations needed. Some areas are simple and uniform, or have distinct soil-landscape relationships, and so require fewer observations. The purpose of the map also has a bearing on the number of observations required.

The guidelines remove judgement and discretion for observations and replace it with a mandatory observation density. This is good for ensuring the map is presented at the appropriate scale. However, in some cases it creates significant unnecessary work for the consultant, as well as significant cost for the client.

For example, I recently undertook a LUC map of one hectare to help determine the presence and extent of High Class soil. The area had a simple and predictable soil pattern. Slope was the overriding factor in this assessment and the site was all flat to gently undulating. Six auger observations and the soil-landscape pattern confirmed the soil pattern and showed no unusual activity at the site. The land owner was also intimately familiar with the soils having worked the site for 40 years. My professional opinion was that the site was LUC 1 and 2 land and, therefore, High Class Soil. I produced a map for the hectare that was about 100 cm^2.

Applying the guidelines to the above example shows it was woefully inadequate. Guidelines to determination of high value food areas require 1 observation per cm^2 of map. I was short 94 observations! Of the required 100 observations 65 were to be auger borings, 10 were soil profile description pits and 25 could be visual clues. I could present the map at an appropriate scale for the six observations I made, but it would be the size of a postage stamp. Even at a medium scale of observation density it would have required 47 observations. This is an example of increasing effort with little or no benefit for the outcome, or for the client.

I do not agree with the site density guidelines for more detailed scales. They are too prescriptive and need flexibility to allow for fewer observations based on professional experience, sound knowledge of the area, its landscape and soils, and local variation. These issues with detailed scales need to be addressed (especially below 1:10,000, and maybe the guidelines should not be applied to these larger scales).

<u>Implication 5: Increased accountability and legal exposure</u>

Previously there was no standard for soil mapping. Now the new Guidelines can be incorporated into a project brief and on completion the project can be assessed according to how it has met the standard. The standard becomes a performance measure. This is positive and provides a level of rigour and certainty for the client.

The other aspect is that reports or maps that do not comply with the guidelines potentially expose the consultant or agency to litigation. Particularly if investment decisions based on the map are proven to be incorrect. I believe S-map is very exposed given its use at 1;10,000 scale for farm-scale advise for Overseer and Dairy Shed Effluent irrigation risk. The farmer is using S-map for Overseer and Dairy Shed Effluent irrigation decisions. Effluent systems can cost $100k to $200k. To base this investment on farm-scale mapping with zero observations, rather than the required 50, is high risk. It would be better to have no map rather than one which is not fit for purpose. To ignore good practice and knowingly provide inappropriate data for investment decisions contributes to the reasons people mistrust scientists and institutions. It undermines credibility.

Any soil map evidence presented at a hearing for environment court will immediately be scrutinised and a competent lawyer will ask 'does the map comply with the National Soil Mapping Protocols and Guidelines?' If the answer is 'no' then that is an issue. This means that any mapping, or decisions based on the soil map, that may go to a hearing or court must follow the guidelines (even if they are inappropriate) or risk being discredited. This has implications for regional council plan changes designed to reduce nutrient leaching and runoff and applied at the farm-scale using S-map data.
I agree with increased accountability.

Implication 6: Taxpayer, ratepayer and client costs will increase

Soil investigations are a means to an end. They are not an end in them self. Farmers want to know where their high and low risk leaching areas are, about areas suitable for winter effluent irrigation, drainage, soil suitability for particular crops, why the pasture isn't responding as usual. They are generally not interested in requirements in the Guideline for soil classification, profile descriptions or spending a lot of effort on density of observations for little or no gain. There are requirements for five per cent of the observations to be soil pits for detailed descriptions. Soil pits are time consuming to dig, describe and transcribe and add no value to the outcome for the farmer.

In the Guidelines are other examples of unnecessary data collection. For example, dairy shed effluent is potentially a polluting substance and mapping for irrigation assessment is at 1 observation per 2 cm^2 of map. However, mapping for industrial effluent requires twice the density of observation. I don't know why this would be the case. Industrial application requires a consent, the effluent is usually more processed than dairy shed effluent and there is rigorous monitoring. Requirements for the soil map will vary depending on the location and type of industrial effluent. It is not reasonable to double the cost on industry when they are managed by resource consents.

Measurement is another example of unnecessary cost imposed by the Guidelines. Measured soil properties for Overseer and land treatment need to be at a density of 1 per cm^2 of map. So, for your average 100 ha dairy farm that is 100 measurements. Am I expected to do 100 infiltration measurements? I hope not, but it's not clear in the guidelines. The method is also prescribed which is a bit much (Table 8). Does that mean I use the suitable method then repeat the sampling using the prescribed method? The pedologist needs to be given some credit for knowing their job.

Mapping for S-map is at an average observation density of 1 per 2 cm^2 of map. If a region has large areas of DOC managed land or steep land that does not require such detail, then to maintain the average density (according to the Guidelines) the other land has to have an increased number of observations. These unnecessary observations cost the ratepayers who get no additional benefit. It is not reasonable to increase observations beyond what is needed just to increase the average density to comply with the Guidelines.

The guidelines should not be used as a vehicle to obtain data other than what is required for the project. The inclusion of unnecessary mandatory standards, or information gathering, is probably so '*Consistency of approach will go some way towards facilitating individual farm data to be combined for broader catchment and regional objectives*' (p8 of the report). This additional cost is in effect a targeted rate. Rates increases, and targeted rates, need to go through a formal council process. But here they are being introduced via the mandatory standards in the Guidelines. This is an unfair financial burden on the client and does not follow councils democratic process.
Using the clients mapping information for other council or research purposes is not usual practice. Client confidentiality, and use of data they own, is something to be negotiated with the client. The assumption that client data and maps will become public property is not correct.

Cost benefit analysis is a useful tool to help determine which requirements in the Guidelines are important. For example, Barringer *et al* (2016) found that mapping soil at about 1 observation per 2 cm^2 of map (they had 55 for a 120 ha farm at 1:10,000) gave the same result as 726 observations and reduced cost from $12,000 to $1,000. Their study used a grid pattern and ignored the clues of the soil landscape. Had the soil landscape model been applied then I would suggest there would have been an increased accuracy and a further reduction in observations (and cost). And that highlights the problem of prescriptive approaches. The Guidelines do not give credit to professional intelligence.

Soil mapping cost increases draw on the public via taxes, rates and invoices. Unless absolutely essential, costs should not be added for data collection that is not relevant to the client or adds little improvement. Only what is required for that individual project should be expected. Guidelines remove discretion and can impose data requirements that are irrelevant to a particular task. This is bad for the taxpayer, ratepayer and client.

I disagree with the removal of professional judgment in the field, and mandatory prescriptive sampling and data collection requirements which are not relevant to the outcome of the mapping project. It will significantly increase costs. In the case of regional councils', the increased data requirements will cost ratepayers millions of dollars. The cost of unnecessary data collection is a significant issue.

What to avoid

A national mandatory process

One danger to avoid is that the guidelines could follow the process of that grew out of the Soil Contamination Guidelines. This could look something like this...

- The consultant visits the site and determines the level of observational density depending on the purpose of the map and complexity of the likely soil pattern.
- The proposed mapping and sampling approach is submitted to council for approval.
- The consultant undertakes the mapping and sampling. Produces a report and submits it to council for approval.
- Council approves the report or requests further information, more sampling or observations etc.
- The report is resubmitted to council for approval.
- If approved the report is sent to the client.

A maxim of soil contaminant testing is 'absence of evidence is not evidence of absence'. Following this maxim, you can expect to do a lot of observations even if you think they are unnecessary. You may well end up being correct, but now you can prove they were unnecessary. Under this model professional discretion and judgment is removed from the mapper and replaced with a recipe approved at the discretion of council. This can become a very expensive and lengthy bureaucratic process for you and the client.

Double standards

Another possible danger is double standards for agencies and consultants. The argument is that soil mapping is expensive for a region and, therefore, a different standard should be applied. I would argue that it is expensive for the client as well. Double standards cannot be justified in this case.

Change the definition of 'observation'

Any revised guidelines should avoid defining S-map's computer-generated digital soil mapping (DSM) points as observations. These are not field observations but mechanical guesses. Some might regard their inclusion as inappropriate, but I'm not necessarily against it providing they are not called observations and the map scale is equal to that of the worst data used (this means S-map will be limited to 1:50,000). However, I would want similar 'observations' that were made in the field by other mappers to also be valid for their soil mapping.

I've acquired an advanced computer and image analysis system that I take into the field. It can rapidly analyse millions of points on the farm for topography, vegetation, surface condition, roughness, and calibrate those against measured soil observations and historic data. The data, using a neural feedback mechanism, then directs the evolving sampling design to maximise sampling efficiency for the site. These generated points are more precise and accurate than DSM because they are developed on-site using actual real time data. Provision needs to be made in the Guidelines for inclusion of observations collected using this advanced data gathering system. The system is portable and housed in a robust waterproof container called Head. The processing package is called Brain.

Not using professional input

A professional's field analysis does deserve more credit and status than given by the Guidelines and undervaluing it should have been avoided. Professional expertise will reduce costs and increase utility of the final map. Field observation based on the complexity of the soil pattern and confidence of the developing soil-landscape model can alter the position and number of observations. To relegate professional expertise to second place behind a mechanical grid process discounts the contribution to efficiency and cost saving derived from a pedologists soil mapping skills. Wouldn't it be better to acknowledge the profession of pedology and the cost-benefit it has for targeted collection of soil information in the field? Not to do so discredits the contribution of pedology which is bad for the client and bad for the science.

I can see no reason why there shouldn't be a required professional standard of expertise to be able to produce soil maps. Councils should not accept maps from unqualified consultants. Councils have a list of approved contaminant consultants and I see no reason why this cannot occur for soil mapping consultants.

There is nothing worse than getting an unqualified person doing auger inspections and not knowing what they are looking at and producing rubbish. These guidelines don't stop that from occurring. A list of approved professional mappers does.

A solution

A possible solution to some of the issues I've raised is to rename the report 'Regional Council soil mapping protocols and guidelines'. Regional councils were the client for the report and, other than Landcare Research, were the only staff on the Technical Advisory Group. I'm not aware that there was a call for national soil mapping standards, so the guidelines were to fill a regional council need.

By making the report for regional councils they can then apply the guidelines on a case-by-case basis. They also have the flexibility to modify the requirements for each application. More work on the guidelines is needed to cover councils' main uses such as farm-scale maps for determining areas of high-class soil, nutrient budgeting and dairy effluent irrigation. The scale requirements for S-map also need revisiting. However, with these modifications I think the guidelines can be a useful tool for councils.

Of course, the simplest solution is to use professionals for soil mapping. Mapping requires expertise and the parts of the guidelines can be included in the contract to ensure quality control and prevent, for example, producing S-map at the wrong scale. This acknowledges the profession of pedology rather than undervaluing it.

Final thoughts

Looking into the implications of the New Zealand Soil Mapping Protocols and Guidelines highlighted several issues for me. One was the narrow scope of representation on the Technical Advisory Group which only included Landcare research and regional council staff. This group would have benefited from a broader range of experience and representation and this would have improved the document

outcomes. Having a breadth of experience and representation is essential when developing what could be nationally applied protocols. Consultation is also needs to be more than sending people an email and instead needs to be genuine engagement.

Soil science in New Zealand does not reside in a single organisation. Hopefully an improved more inclusive process will occur with the current revision of Soil Survey Method and New Zealand Soil Classification.

Finally, I am in favour of the requirement for some form of Soil Mapping Protocols and Guidelines. The current guidelines begin to provide a level playing field, even if the ground's still a bit bumpy and requires significant levelling.

Thanks for your interest.

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[1] http://www.envirolink.govt.nz/assets/Envirolink/Tools/R12-4-New-Zealand-soil-mapping-protocols-and-guidelines.pdf

Special Feature: Kainui silt loam

Origin and classification of Kainui silt loam: update on the leopard that changed its spots

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Introduction

Around 30 years ago, the editors of *New Zealand Soil News* (Val Orchard and Lee Searle at the time) invited members to contribute short articles on their 'pet profiles' – that is, on a representative soil of their favourite series, describing key morphological and other features and explaining why the soil is important. I wrote such an article in 1991 on the Kainui silt loam (Lowe, 1991), a soil on which I had worked for part of my masterate research. Funnily enough, my article, number 11, was the last 'pet profile' to be published (Table 1). I have always wondered why. Perhaps the answer lies with the massive upheaval of science in New Zealand that occurred on 1 July 1992, when the CRIs came into existence. Possibly no one had

time thereafter for 'frivolities' such as writing simple, short articles of interest to a wide readership? All the pet profiles provide useful information, unique insight, passion, and humour in just a page or two. We should resurrect the series.

Table 1. Pet profiles published in *NZ Soil News* 1988-1991

Author	Profile no.	Soil (series)	Year
David Lowe	11	Kainui	1991
Peter Singleton	10	Hauraki	1990
Wim Rijkse	9	Katikati	
Ian Smalley	8	Timaru	
Geoff Mew	7	Mahinapua	
Bob Lee	6	Addison	
Wim Rijkse	5	Opotiki	
Roger Parfitt	4	Egmont	
Michael Leamy	3	Conroy	1988
Wim Rijkse	2	Taupo	
Peter McIntosh	1	Otama	

Why Kainui? To paraphrase Churchill, it is a riddle wrapped in a mystery inside an enigma. No other soil provides such interest at the heart of pedology: puzzling origins, perplexing mineralogy, and problematic classification. Summarised below are some of the advances since 1991 regarding the Kainui silt loam and its genesis and classification. I have published a more detailed account elsewhere (Lowe, 2019).

Origin of Kainui silt loam: key features

Key points about the Kainui silt loam (Kainui soil hereafter) are many, perhaps the critical one being the need to appreciate that soil stratigraphy – the interplay between geological deposition, soil formation, buried soils, and their chronological relationships, sometimes called pedostratigraphy (e.g. Palmer, 2013) – is central to understanding the soil's genesis, character, and classification. An Ultisol, the Kainui soil occurs widely on near-level summits, shoulders, and upper-middle backslopes of low rolling hills, and old terraces, of Mid-Quaternary age in and north of Hamilton city in the northern Hamilton lowlands, and in parts of the Piako and Hauraki areas to the north and northeast of Hamilton (McCraw, 1967; Bruce, 1979; Wilson, 1980; McLeod, 1984a, 1992; see also S-map online). It is essential to be aware of this distribution and realise that south of Hamilton (between Hamilton and Ohaupo), the Kainui soil morphs into soils of the Ohaupo and Otorohanga series, both of which are Andisols, mainly on rolling hills and hills in the Waipa area (Barrratt, 1981; Orbell, 1983; McLeod, 1984b). Reasons for differences between the Kainui and Otorohanga soils are described in Lowe (2019).

(1) The Kainui soil is a two-storeyed soil, the upper storey c. 0.4 to 0.7 m thick (c. 0.6 m on average) comprising a composite silt-rich coverbed of multiple, thin tephra layers deposited incrementally since c. 50,000 years ago (commonly denoted 'late Quaternary') overlying a buried paleosol on older, strongly weathered clay-rich Hamilton Ash beds (the lower storey) (Fig. 1). The profile *in toto*, extending to a metre in depth, thus encompasses two main 'units' easily seen in road cuts when the profile is dry because of the contrasting colours and textures.

Figure 1. Left: *A long section exposing weathered tephras, including the Hamilton Ash beds, in a road cut on Gordonton Road about 3 km north of Hamilton (37°42'21" S, 175°18'14" E) (very near Zealong Tea Plantation). The dark reddish-brown soil horizons on the upper Hamilton Ash probably represent a paleosol dating back to the Last Interglacial, or Marine Oxygen Isotope Stage (MOIS) 5e. On top is the thin, silty coverbed of multiple late Quaternary tephras that have accreted one-by-one over the past c. 50,000 years. The paleosurface boundary, a lithological discontinuity, is distinctly wavy or irregular and marks tree-overturn hollows and mounds. The coverbed deposits are occasionally overthickened in the hollows that can be up to c. 1.2 m deep locally. In such deep hollows (>c. 0.8 m), upper profiles sporadically can be allophanic rather than halloysitic (Lowe, 1986). Near the base of the section is Rangitawa Tephra, aged c. 340 ka (pale bed at far left). It overlies unconformably a tiny remnant of a truly ancient landsurface represented by a buried, extremely clay-rich soil on bed K15, or Waiterimu Ash, of the Kauroa Ash sequence (Ward, 1967; Lowe et al., 2001). K15 is aged >c. 780 ka. Seb Lowe provides the scale. Photo: D.J. Lowe.* ***Right:*** *Profile of the Kainui soil at Gordonton Road comprising two distinctive parts separated by the lithological discontinuity (dashed line). Formed by developmental upbuilding pedogenesis, each component of the upper profile has previously been an 'A' horizon whilst the land surface has risen slowly since c. 50 ka as thin tephras were accreted at the site. Redoximorphic features in the Bw(f) horizon (>2% Mn-Fe concretions with some mangans) indicate prolonged periods near to saturation because of perching on the buried paleosol marked by the 2bBt(f) horizon. Consequently, the entire soil is dominated by halloysite, not allophane, because of limited desilication (Lowe, 2019). Photo: R. McEwan.*

The soil looks much like the 'strong texture-contrast' or 'duplex' soils that are especially common in Australia (e.g. McKenzie et al., 2004) but it has quite different origins. Earlier ideas of the coverbed comprising loess (McCraw, 1967) were discounted because the mineralogy of the mantle is pyroclastic in origin (although the clay minerals did not seem 'to fit' that origin, as discussed below), and because adjacent 22,000-year-old (22 ka) lakes in the Hamilton lowlands contained in their organic-rich sediments many thin but well-preserved visible tephra-fall layers (Lowe, 1985, 1988, 2002).

These lacustrine tephra deposits (in the millimetre- to centimetre-thickness range) therefore provided an integrated 'dossier' of tephra fallout over the landscape since c. 22 ka. Equivalent thin, subaerial (dryland) tephra deposits make up the upper part of the coverbed (Lowe, 1986). Older, pre-22-ka tephras, include Kawakawa tephra (c. 25.4 ka), Okaia Tephra (c. 28.6 ka), Tāhuna Tephra (c. 39.3 ka), and Rotoehu Ash (c. 50 ka) (Lowe, 2019). The last three tephras were discovered well preserved beneath lake sediments at Lake Maratoto (Green and Lowe, 1985), which is about 7.5 km south of Hamilton (near Hamilton Airport). Earlier mapping of named (correlated) tephras in the Waikato region had been limited to the eastern margins (Pullar, 1967; Pullar and Birrell, 1973) because most of the tephra layers as such effectively petered out as they became thinner farther away (and 'upwind') from their main volcanic sources in the central Taupo Volcanic Zone. They also became shallower and increasingly altered within the soil-forming environment so that their diagnostic physical properties became more difficult to discern (e.g. Hodder and Wilson, 1976; Hogg and McCraw, 1983; Lowe, 1988). These pre-22-ka tephras, dominated by Rotoehu Ash, make up the lower half of the coverbed (Fig. 2), although there has been considerable intermixing throughout the coverbed because of upbuilding pedogenesis, discussed below. The basal age (c. 50 ka) of the coverbed in the Kainui soil stems from the identification of Rotoehu Ash (not 100% pure, but overwhelmingly predominant) in the basal deposits. Rotoehu Ash has been re-dated recently at about 50 ka (Danišík et al., 2012; Flude and Storey, 2016). From the proportions of diagnostic cummingtonite in the ferromagnesian mineral fractions, Rotoehu Ash is estimated to be c. 25 ± 10 cm thick at Rototuna in northern Hamilton, and 30 cm thick at Lake Maratoto.

(2) One of the biggest advances since 1991, when I wrote that the thin multiple tephra layers had been "weathered and blended by soil forming processes", thereby masking their origin, is the recognition that these profile features reflect upbuilding pedogenesis. Upbuilding pedogenesis is the ongoing formation of soil *via topdown processes* whilst tephras or loess (or alluvium, colluvium) are *simultaneously* added to the land/soil surface as a consequence of normal geological processes. The frequency and thickness of tephra accumulation (and other factors) determine how much impact topdown soil-forming processes have on the ensuing profile character, and if either developmental or retardant upbuilding, or both, prevail (Lowe and Tonkin, 2010). Upbuilding pedogenesis is readily envisaged as an ongoing 'competition' between *geology* (e.g. tephra or loess deposition) and *pedology* (transformation of tephra or loessic material into soil horizons). Topdown pedogenesis comprises multiple processes operating mainly from the land surface, driven by the organic and water cycles, that result in the gradual deepening of the profile as a downward moving front in pre-existing parent materials (Almond and Tonkin, 1999). That is, 'classical' soil formation proceeds by effectively modifying a (static) parent material to a greater or lesser extent according to a range of factors that dictate an ensemble of soil processes. Such classical soil formation is thus seen as a two-step process (step 1: parent material emplacement or exposure; step 2: its transformation into soil horizons), whereas steps 1 and 2 occur together, not sequentially, in upbuilding pedogenesis. It is important to appreciate that topdown pedogenesis occurs, nevertheless, during upbuilding pedogenesis, but its effectiveness is lessened as the land rises either gradually (developmental upbuilding) or abruptly when thick deposits are emplaced (retardant upbuilding).

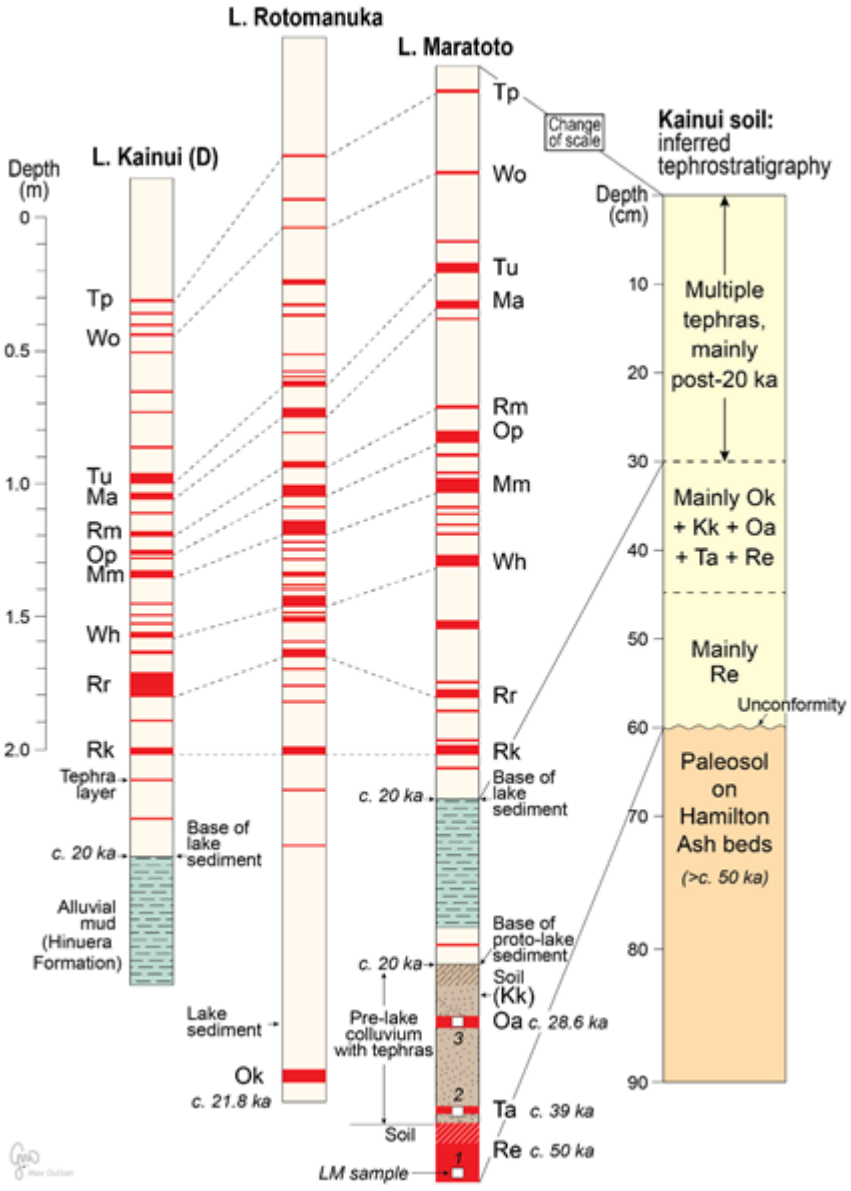

***Figure 2**. Stratigraphy and correlation of tephra layers in lake sediment cores from c. 20- to 22-ka-aged lakes Kainui, Rotomanuka and Maratoto and underlying pre-lake lithologies and buried soils (from Lowe, 2019). Lake Kainui is within c. 7.5 km of the Gordonton Road site shown in Fig. 1. Named tephras and approximate calendrical ages are: Tp, Taupō (1.7 ka or 232 ± 10 AD); Wo, Whakaipo (2.8 ka); Tu, Tuhua (7.5 ka); Ma, Mamaku (8.0 ka); Rm, Rotoma (9.4 ka); Op, Opepe (10.0 ka); Mm, Mangamate (11.3 ka); Wh, Waiohau (14.0 ka); Rotorua (15.6 ka); Rk, Rerewhakaaitu (17.6 ka); Ok, Okareka (21.8 ka); and Kk, Kawakawa (25.4 ka) (not visible as layer). In the lower Lake Maratoto core, the older tephras (ages shown) are Oa, Okaia; Ta, Tāhuna; and Re, Rotoehu. The two buried soil horizons represent disconformities. The column at far right depicts the inferred stratigraphy of the Kainui soil. The boundaries of the coverbed tephrostratigraphy are notional because of continuous tephra admixing during upbuilding pedogenesis. The figure shows that the parent materials of the Kainui soil (to c. 1 m depth) are time-transgressive, spanning an age range that could be as much as c. 125,000 years if the upper Hamilton Ash (which is undated) is as old as c. 125 ka in age (MOIS 5e). To convey the soil's two-storeyed, upbuilding-derived, diachronous character, the age of the parent materials cannot be enunciated by a single number. Instead, they may be described, for example, as 'a composite of multiple tephras younger than c. 50 ka over strongly weathered tephra considerably older than c. 50 ka', or*

as 'a composite of late Quaternary tephras on a buried paleosol on older tephras (Hamilton Ash)'.

The terms developmental and retardant upbuilding were coined by Johnson and Watson-Stegner (1987) and Johnson et al. (1987, 1990). To reiterate, retardant upbuilding occurs when a relatively thick layer of tephra (or alluvium or colluvium) is instantaneously added to the land surface, or where the rate of accumulation of many thin deposits is so fast that the original soil is rapidly overwhelmed, and thus becomes a buried horizon cut off and isolated from the new land surface in which topdown pedogenesis begins anew. Developmental upbuilding, represented well by the Kainui soil (Fig. 1), and by most loess-derived soils, occurs when the rate of addition of tephra (or loess) to the land surface is incremental and sufficiently slow to enable topdown pedogenesis to keep pace as the land gradually rises (e.g. Kemp, 1999; Alloway et al., 2018). At Gordonton Road, the rate of accumulation of tephras in the upper profile averages c. 1.2 mm per century, about the same rate as very slow loess accumulation on the West Coast, South Island.

These concepts of upbuilding pedogenesis form part of the dynamic-rate model of soil evolution whereby soils are envisaged to evolve by 'ebb and flow' through time (Johnson et al., 1990; Schaetzl and Thompson, 2015). A corollary associated with developmental upbuilding is that each part of the profile has, at one time, been an 'A' horizon, which helps explain the pedogenic fabric evident in the horizons making up the upper 'storey' of the Kainui soil.

(3) That the boundary between the upper and lower storeys is a lithologic discontinuity (unconformity) is an important conclusion because it negates several other ideas of genesis that had been invoked previously. One hypothesis was that the buried soil horizon (2bBtg) on the upper Hamilton Ash (Fig. 1) was an argillic horizon (it is, but as a relict feature in a paleosol); another was that it was a podzolic-B horizon. Both hypotheses assume the 2bBtg horizon to be genetically connected by the eluviation of clays, or by the eluviation of Fe, Al, and Si, from the upper to lower parts of the soil, forming a sequum. But the upper and lower profiles are probably not directly connected genetically (or they have been connected for only a limited period): the buried soil has properties (including features that qualify as kandic and argillic horizons) that relate to its formation at an earlier time, probably during the Last Interglacial (Bakker et al., 1996).

(4) The clay fraction of the weathered mantle of late Quaternary tephras is dominated by halloysite, not allophane. Earlier, this had been a major puzzle because the formation of halloysite was erroneously thought to follow, by some ~10,000 to ~15,000 years, the formation of allophane (Lowe, 1986, 2002). However, the development of the Si-leaching model explained that the formation of allophane or halloysite depended in part on the amount of silicon in soil solution, which was in turn controlled by rainfall, drainage, depth to slowly permeable layer, and other factors (Parfitt et al., 1983, 1984; Parfitt and Wilson, 1985; Singleton et al., 1989), age being indirect and subordinate (Lowe, 1986, 2002). This is another key finding: that 'young' tephras could weather directly to halloysite, exemplified in the Kainui soil, was the 'leopard that changed its spots'. In fact, the inverse atomic structures of allophane and halloysite preclude the possibility of allophane transforming to halloysite other than by completely dissolving and reforming (Churchman and Lowe, 2012). The presence of redox segregations, especially MnO_2-concretions towards

the base of the late Quaternary tephra mantle, supported the Si-leaching model because these wet-dry features show that desilication has been limited to some degree (Lowe, 2008, 2019).

Classification

The classification of the Kainui has been troublesome in that the soil, despite its 'young' tephra-derived origins, did not fit into the Yellow-brown loams of the earlier *New Zealand Genetic Soil Classification* because it was clearly non-allophanic (Taylor and Pohlen, 1962, 1968). Nor did it sit well in the Brown-granular loams (typically formed on weathered Hamilton Ash beds) because the 'granular' fabric associated with this group was at a depth of ~0.5 m or more. Instead, the two-storeyed character of the Kainui soil was suitably reflected by its classification as a composite Yellow-brown earth on (pre-weathered) Brown-granular loam (McCraw, 1967; Wilson, 1980; McLeod, 1992). In the *New Zealand Soil Classification* (NZSC), the Kainui soil was initially placed in the Granular Soils (first and second editions) but I thought the earlier composite classification was more appropriate because it fitted the whole (c. 1-m deep) profile morphology better. The Kainui soil has also been characterized previously as having an eluvial and illuvial couplet, namely a pale E horizon over a (translocated clay-enriched) Bt (argillic/kandic) horizon, forming a sequum. However, the soil stratigraphic evidence shows that the Bt horizon is a buried soil, hence is classed as a 2bBt horizon, with the upper boundary representing a lithologic discontinuity. Therefore the sequum is illusory because the E and (2b)Bt horizons are (largely) not connected genetically and are some tens of thousands of years apart in age. Clayden and Hewitt (1989) suggested that the E horizon in such cases should be designated an EBw horizon. Most if not all of the clay skins in the 2bBt horizon are relict. Hence in the third edition of NZSC, the Kainui soil is now, uniquely, a Buried-granular Yellow Ultic Soil; tephric; not applicable (mixed rhyolitic >> andesitic fines); silty/clayey; moderate/slow (Hewitt, 2010; Webb and Lilburne, 2011). The 'ultic' character is well expressed in *Soil Taxonomy*: the soil depicted in Fig. 1 is a Typic Kandiudult; fine-silty over clayey, halloysitic, thermic (Soil Survey Staff, 2014).

What about the buried soil on the upper Hamilton Ash beds?

Athough we now understand the origins and character of the upper storey to a better extent than before, the buried paleosol on the upper Hamilton Ash beds (the lower storey) remains enigmatic, partly because it is so weathered and altered. Of the entire Hamilton Ash sequence, only the basal unit, H1, which is also known as Rangitawa Tephra, has been dated directly (Fig. 1; Lowe et al., 2001). The white, ~0.5-m-thick Rangitawa tephra is c. 340 ka in age and it fell late in MOIS 10 (Pillans et al., 1996). Rangitawa tephra is overlain in turn by the ~3-m thick sequence of weathered, yellowish brown to brown to reddish brown clayey tephra beds and buried soils – the Hamilton Ash beds – that must represent MOI stages 9 to 5. Partly on the basis of the colours of the beds in the sequence and the climatic associations developed by other workers in similar materials elsewhere in central North Island (e.g. Stevens and Vucetich, 1985; Alloway et al., 1992), the uppermost distinctive, dark reddish-brown buried soil, known also as the Tikotiko Ash or bed H6/7, probably represents MOIS 5e with an age of c. 125 ka (as noted earlier). Following Stage 5e and subsequent interstadials (5c, 5a) and stadials (5d, 5b), marked cooling into the Last Glaciation began at c. 74 ka. Therefore, the pit-mound windthrow features (Fig.

1) on the paleo-surface on the upper Hamilton Ash allow an approximate minimum age of c. 74 ka to be inferred for this surface because forest cover, almost certainly very extensive during MOIS 5e and prevalent during MOIS 5d-5a, was likely reduced to remnant status in the central Waikato after c. 74 ka with shrubland-grassland being predominant during the Last Glacial Maximum (c. 30–18 ka). Such an age for the paleo-surface could be tested using several radiometric dating methods provided suitable zircons could be extracted, by undertaking paleomagnetic measurements to try to identify the Pringle Falls excursion/event at c. 220 ka and the Blake excursion/event at c. 120 ka, and by extracting quartz grains containing melt inclusions (i.e. glass), which could be analysed by electron microprobe as a compositional ''fingerprinting' tool (Lowe, 2019).

Micromorphology

Clay coatings and other micromorphological features in the (now buried) horizons in the weathered upper Hamilton Ash beds match those identified by Bakker et al. (1996) in the Naike clay loam, which is an equivalent (paleo)soil formed on Hamilton Ash that has been exhumed (Lowe, 2008). Bakker et al. (1996) wrote that the laminated character of the clay coatings in the Bt horizons of the Naike soil indicates clay illuviation, and that the fine-clay/total-clay ratios for the Naike soil are consistent with this interpretation. The clay skins, infilling pores, then led to the formation of iron (hypo) coatings. The question then arises as to the source of the translocated clays in the 2bBt horizons because, as has been discussed, the upper late Quaternary tephra mantle accumulated only during the past c. 50 kyr, meaning that overlying soil materials that potentially provide an eluvial source of fine clays were absent, or relatively thin for much of the time as the tephras accumulated incrementally. Also, the upper mantle can comprise Bw(f) and Bw(g) horizons that are pale because of seasonal gleyisation rather than because of eluviation (which could still occur) (see section 5, “Caught in the act”, in Lowe, 2019, p. 17). Could additional tephras covering the 2bBt horizons at the time of the Last Interglacial have been eroded, possibly in MOIS 4, and then effectively replaced during MOIS 3 by the Rotoehu Ash and ensuing younger coverbed tephras we see today?

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