Welcome to the Soil News

May 2018
Issue #2 - Vol #66

ISSN 1178-8968 (Online)

In this issue...

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

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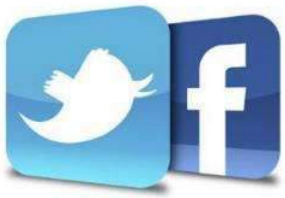

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2016-2018

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Editorial

Can we protect our soil biodiversity?

The long geographic isolation of New Zealand has led to one of the highest rates of endemism globally. Approximately 80% of our plants, 70% of our birds, and all bats, amphibians, and reptiles are not naturally found elsewhere. While we can be proud of our unique biodiversity, we are also towards the top the leader board for species loss (extinction) and invasions of weeds, pests, and diseases. Every other week we seem to hear of a new threat to both our productive and native ecosystems. One must wonder how many potentially damaging organisms cross New Zealand's borders but don't establish, or simply go unnoticed?

While we have a reasonable understanding of what is happening in our above-ground ecosystems, below ground it's a different story. This is somewhat paradoxical, as most of New Zealand's biodiversity resides in our species-rich soil ecosystems. Of course, most of this diversity is microbial - but just because we can't see it, does it mean it doesn't matter? We certainly value the importance of soil biology when we consider the consequence of its activity: these manifest in a range of ecosystem functions (or services), such as the cycling of nutrients, as a sink and source of carbon, the source of the plant and animal microbiome (spanning clover root nodule forming rhizobia through to facial eczema disease), N_2O emissions and so on. As we continue to comprehend the importance of this hidden microbial world to the operation and maintenance of our natural and productive ecosystems, it becomes clear that preserving soil biology and function is important for all our futures.

There is considerable uncertainty regarding how land-use change, ecosystem intensification, climate change, and other disruptive events will affect soil biology. However, it is widely recognised that building resilience into these ecosystems via maintaining high diversity will underpin the sustainable provision of ecosystem services. Furthermore, understanding soil biology may see shifts in the paradigm of production and environmental protection being a trade-off, towards a focus on leveraging environmental protection as a positive and value-enhancing attribute. We could see a change in product value, where enhancement and provenance of local soils, and preservation of native soil biology, leads to increased value and access to markets of NZ food and fibre products. Given the famous terrior French wine has as microbial component associated with the soil-plant ecosystem[1,2], can a unique 'terrior' associated with the horticultural and agricultural products derived from New Zealand's soils be established?

Unfortunately, our understanding of soil ecosystems is in its infancy compared with their above-ground counterparts. We remain largely ignorant of the extent of life present in New Zealand soils. We have no idea how much of soil biological diversity in New Zealand is endemic. Does the high rate of endemism in birds, reptiles, and trees extend to soil bacteria, archaea, and eukarya? What are these species and what do they do? New Zealand could be gaining or loosing entire guilds of organisms and we would have no idea. Mass extinctions and mass invasions could

be happening belowground, as much as those above. If so, have we passed a point of no return, or are we approaching this precipice? Shouldn't we know this as a nation and guardians of its biodiversity? If not for the species, then at the very least for the clean water, plant production, nutrient cycling and other ecosystem services they provide.

This begs the question, how can we protect our soil biodiversity? A first step is gaining a more complete understating of the soil biodiversity we currently have, how it varies across New Zealand's regions and land uses, and what changes are occurring over time. To achieve this, we need to be collecting and storing the biological signature (DNA) of soils during routine archiving efforts. Thus, future soil archives should comprise not only the physicochemical matrix of the soil (typically our dried and ground mineral fraction), but also the biological component that provides life and function to soil ecosystems. Efforts are progressing towards achieving this, including suggestions for the standardisation of sample collection and preservation. However a standardised, pan-sector methodology appears some time off. Furthermore, if we base our DNA extraction methods on commercially-produced kits, we run into the very real risk of future method modifications (companies, reagents, etc change).

Today, it would be wonderful to interrogate the DNA of New Zealand soil samples going back 60+ years. What changes have happened during European settlement and expansion, how have the ecosystems changed and evolved, what signatures are there for climate change, land use alteration etc. If we knew these things, we could predict what impacts current events will have on future ecosystem function. Surely, however, if we don't start archiving the biology of our soils today, we will be saying in another 30 years "imagine what we could be doing if we had samples going back the last 90 years….."

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[1] PNAS (2014) 111: 5-6
[2] mBio (2015) 6:e02527-14

President's message

Message from the President

Kia ora NZSSS members,
I ended my last President's message discussing the push for a National Policy Statement (NPS) for versatile soils from some of our membership. Well I'm sure you are all aware that great progress has now been made in this regard. The Ministry for Environment released their 'Our Land' Report in April (http://www.mfe.govt.nz/publications/environmental-reporting/our-land-2018). The report highlights the following key issues: the loss of high class versatile soils to urban expansion, changes in land use (in particular the increase in dairy-farmed land), data from monitored soil properties and biodiversity over time. The report represents a useful state of play for our essential soil resource while in addition it resulted in some excellent publicity through print, radio and television media. The icing on the cake for this excellent day of soil media coverage came when Minster for Environment David Parker suggested that they were interested in exploring the opportunity for a NPS on versatile soils. In response to this suggestion the Society has prepared and sent a letter to the Minister encouraging his endeavour in this area and offering our support in its potential development. The letter from the Society is appended below this note.

Some good news to report with regards the International Union of Soil Sciences (IUSS) elections. Megan Balks was elected as Vice Chair of IUSS Commission 1.3 Soil Genesis, and Prof Leo Condron was elected as 2nd Vice Chair of Division 2 Soil Properties and Processes. Both positions will become effective following the World Soils Congress meeting in Brazil in August 2018. Voting results from 35 national societies with 127 000 individual votes were received. Elections were decided by a simple majority of votes cast. It is a credit to the international profile of our NZ candidates that they were successful in such an election where each had competing nominations.

Finally a reminder to all to prepare an abstract (and register) for the upcoming NZSSS conference in Hawkes Bay in December. The local organising committee are currently working on securing some interesting and thought provoking keynote addresses, which will soon be confirmed. In addition they are arranging three excellent field trip options that showcase the multiple land use options and soils present within the Hawkes Bay. A big thank you to the organising committee (led by Paul Johnstone and Rebecca Withnall) for all of their work to date. The final day for abstract submission is July 6th so please consider what you may like to present in either oral or poster form. I hope to see many of you there.

Regards Dave Houlbrooke – NZSSS President

Hon David Parker - Minister for Environment
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New Zealand

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24 May 2018

Dear Minister Parker

Endorsement of a National Policy Statement on versatile land and high class soils

The New Zealand Society of Soil Science commends you on your request to develop a National Policy Statement on versatile land and high class soils. The soil science community in New Zealand considers this issue to be of prime importance to ensure the vital role that versatile land and high class soils play in the future provision of food and primary production in New Zealand remains viable.

The New Zealand Society of Soil Science was formed in 1952 and is a professional society to encourage the advancement of soil science in New Zealand and internationally. It has over 350 members including New Zealand and overseas based professional soil scientists, soil science academics, environmental scientists, ecologists, geographers, agricultural scientists, foresters, engineers, geologists, farmers, teachers, and consultants.

Our Society promotes sound management of the environment based on an understanding of soils and their importance in ecosystems and provides national and regional guidance on issues concerning land and soil resources.

Over several decades our Society has advocated for the recognition of the importance of versatile land and high class soils, including correspondence with various ministers. In recent years, we have contributed submissions to Government and the Parliamentary Commissioner for the Environment highlighting that development needs to respect this valuable, irreplaceable resource.

We have encouraged members to submit where appropriate on regional and district plans (and plan changes) to highlight areas where soils can be better managed or where there is risk of vital soil resources being lost to urban development.

As a Society, we extend our support to you and your officials and are prepared to assist where we can.

Again, we applaud you on your recognition of this issue and intent for a National Policy Statement on versatile land and high class soils.

Yours sincerely,

Dr David Houlbrooke – President New Zealand Society of Soil Science

Society News

2018 NZSSS Conference

3-6 December 2018, Napier, New Zealand

Soils2018 will be held in Napier from 3 to 6 December 2018. This biannual conference is a must attend event organised by the NZ Society of Soil Science and OnCue Conferences, and will cover a range of topics under the theme 'diverse soils - productive landscapes'. All of the details about this event can be found at the conference website: http://nzssconference.co.nz/. See full advert in the Conferences section further down.

Soil-art exhibition - invitation and advance warning!

After our successful inaugural soil art exhibition at the Hamilton conference in 2014 we are again planning to hold a soil-related art exhibition at our NZSSS conference in Napier. We would like to showcase the widest possible interpretation of soil-related art, produced by you, the New Zealand Soil Science community.

Everyone can participate - all forms of art will be accepted including: sculpture from soil/clay/earth materials or with a soil-related theme, paintings related to soils or madeusing soil materials, poems or short statements that can be displayed on a wall poster, photography, fibre art, computer generated art, soil peels, sand paintings, cartoons –everything is possible.

Get committed, let Megan Balks megan.balks@waikato.ac.nz or Diana Selbie diana.selbie@agresearch.co.nz know if you plan to contribute so we can ensure we have enough suitable display space.

News From the Regions

Waikato/Bay of Plenty

Waikato University

Megan Balks, who retired in February this year, is enjoying a more flexible lifestyle as an "Adjunct Senior Research Fellow" at the University of Waikato. She is busy with writing work and still overseeing three MSc students as well as undertaking a range of commitments to the Soil Science Society and the International Permafrost Association (IPA). Megan will be attending a Regional Conference on Permafrost in Chamonix, in France, in June. Megan is the lead organiser of the 2019 Regional Conference on Permafrost which will be held in Queenstown in December 2019. The Queenstown conference will be the first IPA conference to be held in the Southern Hemisphere.

David Lowe has just returned from the annual 'Quaternary Techniques' short course run by GNS Science at the National Isotope Centre, Lower Hutt, with seven students from his Quaternary paper taking part this year. He is also busy preparing to attend the forthcoming tephra conference "Crossing New Frontiers: INTAV International Field Conference on tephrochronology 'Tephra Hunt in Transylvania'", Moieciu de Sus, Romania, from 24 June-1 July 2018. Being held in the southern Carpathian Mountains near the medieval city of Brasov, the meeting is shaping up to be a terrific event with nearly 100 registrants and 95 papers being presented (42 oral, 53 poster) along with seven keynote talks and one public lecture. Tephra studies are in great shape at present, in part driven by the new generation of cryptotephra specialists. "Cryptotephras" (meaning 'hidden' tephras) are glass shard concentrations insufficiently numerous or too fine grained to be visible as a layer to the naked eye. The group will spend four days in the field, with a mid-conference excursion to nearby Bran Castle (home of 'Dracula') and the Persani basaltic volcanic field as highlights. A three-day post-conference trip will examine proximal rhyolitic tephras aged as young as 30,000 years and associated paleosols, and distal Italian-derived tephras preserved in loess and paleosols along the Danube River, and many other Quaternary science features including along the coastline of the Black Sea. An Icelandic tephra has just been discovered as a cryptotephra in lake sediments in the field area. Interestingly, the terms 'rhyoliticc' and dacitic' derive from Transylvania.

AgResearch

AgResearch scientists descended on Lincoln for their biannual 2-day science conference. The programme was a mix of outside speakers and work sessions for multi-disciplinary teams to develop project proposals for addressing some of the BIG challenges facing NZ agriculture. The final session was pitching these big ideas in a 'Dragon's Den' (although some of the feedback was that the dragons were too nice!). The four best ideas will receive AgResearch SSIF support next year. Results to be announced soon. Post conference feedback on the 2 days was very positive: purely coincidental that AgR soils scientists were on the organising committee.

It may be National Tech week but **Mark Shepherd**, presenting to an audience at Waikato's innovation Park, still managed to squeeze in an in-depth presentation on

the urine sensor and why it is a potential game-changer for our science. But just to balance the presentation he also spoke about drones and lasers: probably much more in line with what the audience were expecting.

Stewart Ledgard and **Jiafa Luo** were invited as key researchers at an international Symposium in Green Development in Agriculture in Beijing, 23-27 April 2018. At the Symposium, Dr Ledgard gave an invited presentation on "New Zealand agricultural production, environmental impacts and life cycle implications" and Dr Luo gave an invited presentation entitled "Challenges for New Zealand dairy farming and managing effluents. Over 200 scientists, researchers, government policy officials and students from China and around the world attended the workshop. The workshop discussed potential future development to meet the goal of sustainable agriculture. A number of interesting ideas were discussed, including integrated crop-livestock production towards agricultural green development.

Photos: Left - Fertiliser spreader on a collective farm visited in China. Right - Poster on efficient fertiliser use involving drones and precision placement on the same collective farm (!).

On the 12th of April the Sustainable Nutrient Management on Peat Soils SFF group held their annual field day – it was actually the third time in a row that it has been held on the 12th of April making it a truly 'annual' event. This was attended by approx. 80 local farmers, consultants and industry representatives. **Bill Carlson** (AgResearch) presented findings on the drainage water quality monitoring study which showed differences between peat development status and the relative risk for P vs N losses. **Dave Houlbrooke** (AgResearch) presented the findings of the lysimeter study which backed up the findings of the drain water quality monitoring as well outlining the impact of different dairy effluent management practices. **Scott Fraser** (Manaaki Whenua Landcare Research) presented the peat soil classification tool designed to help farmers determine the risk factor for dairy effluent management. The field day was rounded off with **Murray Lane** (Ballance) presenting on the topic of pasture persistence on peat soils.

Photo: Field day participants looking at a soil pit in the peat soil that Scott Fraser claimed he dug by hand the night before.

Lincoln Agritech

Lincoln Agritech staff have used the dry summer conditions to prepare our field sites for the winter drainage season. In particular, our denitrifying bioreactor in the Hauraki plains has had some modifications done (Figure 1) to prevent blockages and back-flow of drainage water experienced during a couple of last year's storms.

Figure 1: Tasman McKelvey operates the skid steer loader at the denitrifying bioreactor site.

Tasman McKelvey can still be seen in Fig. 1 operating our skid steer loader, but unfortunately he left us at the beginning of May to join PDP in Auckland. While we are sad to see him go, we wish him all the best in his new role.

The International Interdisciplinary Conference on Land Use and Water Quality (LuWQ) has announced dates for 2019. The conference, aimed at scientists, land

and water managers and policy makers will be held in Aarhus, Denmark on the 3rd to 6th June 2019, with abstracts due in by 15th October 2018.
Visit www.LuWQ2019.dk, or contact Roland Stenger (Roland.Stenger@lincolnagritech.co.nz) for more information.

Waikato Regional Council

The soils scientists at WRC are working on a soil strategy to guide the soil-related work undertaken by WRC, now and into the future. The Strategy seeks to provide an aspirational vision of the desired future for the soils our region and a clear pathway for achieving that vision.

Reports readers might be interested in are now available on our website (https://www.waikatoregion.govt.nz/services/publications/land-and-soil/land-and-soil-chrono):

- **Soil stability in the Waikato Region – 2012.** TR 2016/20, A L Taylor
- **Trends in Soil Quality Monitoring data in the Waikato region 1995-2015** TR 2017/26, Matthew Taylor (Waikato Regional Council), Neil Cox (NeilStat Ltd), Ray Littler (University of Waikato) and John Drewry (Greater Wellington Regional Council

Manawatu

Plant & Food

In April, **Brent Clothier** and **Steve Green** completed their last trip to Kenya on PFR's NZ Aid project to improve the livelihoods of the small-holder farmers in the Central Highland. This project began in October 2013, and over the last 4.5 years, a lot has been achieved.

The first job this trip was to decommission the seedling irrigation trial at Peter Maina's farm near Karatina. New avocado seedlings require manual watering during the two dry periods between the rainy seasons. Job done.

Steve Green (right) celebrates the decommissioning of the seedling irrigation trial with (from right to left) the farmer Mr Maina, his son Lewis, and Olivado's Sarah Murigi. The tea and sweet potatoes hit the spot.

The other task was to complete the Decision Support Tool (DST) for the farmers and the private partner in this PPP (public-private partnership) aid-project, Olivado. The DST provides up-to-date information to the farmers by SMS texting, via Olivado, of weather conditions, local soil moisture conditions, farm-practice advice, plus a prediction of the time-to-harvest (TTH) for the farmers' avocados for fresh, and for oil processing. Also the TTH also provides a prediction of the timing of fruit maturity, and the total inflow of fresh fruit to Olivado's packhouse, and then the fruit for the oil processing factory from all of their 2,400 contracted farmers. Another job done.

Steve Green, handing over (literally, it seems!) the farmer and fruit-processing Decision Support Tool (DST) we've developed. Steve is carrying out the final training with the staff of Olivado at their factory near Murang'a.

Karin Müller spent April and May in Italy visiting Prof Francesco Morari's team at the DAFNAE (Dipartimento di Agronomia, Animali, Alimenti, Risorse naturali e Ambiente), Padova University. This secondment was part of the exchange activities under the H2020 project PROTINUS 'PROviding new insighT into INteractions between soil fUnctions and Structure' (http://www.protinus.ird.fr/). The project assembles a multi-disciplinary team from France, Italy, Denmark, New Zealand, Mexico and Japan, coming from research institutes and universities as well as private companies. The 4-year project is coming to an end in December 2018.

Karin concentrated during her recent stay in Italy on completing data analyses and writing up research conducted in the frame of PROTINUS. She is leading several projects where X-ray Computed Tomography (CT) was applied to analyse the effect of soil management on soil structure and functions – using soils from New Zealand. The journal 'Soil Research' plans a special issue on PROTINUS and associated research for early 2019.

While in Europe, Karin also participated in an International Workshop organized by the Academia Nazionale di Agricultura held in Bologna on 5th April 2018 and the European Geoscience Union General Assembly 2018 in Vienna. The latter is an annual meeting, where this year about 15,000 scientists from 106 countries came together. She presented research carried out under the PROTINUS project on the effect of long-term irrigation and tillage practices on soil properties and functions.

Manaaki Whenua – Landcare Research

We recently welcomed some new staff to our site to strengthen our soil physics, soil erosion and geomorphology expertise.

Soil physicist, **John Drewry** joined the Soils and Landscapes team, within Manaaki Whenua – Landcare Research in February. John is now involved in soil physics research in the MBIE 'Maximising the Value of Irrigation' Programme and has been reviewing impacts of irrigation on soil physical properties. John has a background in soil research into soil compaction under treading, diffuse nutrient losses and soil quality particularly from earlier work at AgResearch. He was recently at Greater Wellington Regional Council where he was involved in land issues including soil quality and trace element monitoring and was actively involved in the Land Monitoring Forum. John also has a background in catchment water quality modelling and research.

Hugh Smith also recently joined our team, and his research focuses on natural and human-impacted processes affecting soils and the movement of water, sediments and contaminants in river catchments. His career began in Australia where he obtained his PhD from the University of Sydney and then worked as a research fellow at the University of Melbourne investigating fire effects on soil erosion and water quality. In 2011, Hugh moved to the UK when he was awarded a EU Marie Curie Fellowship and in 2013 became an academic at the University of Liverpool. This year Hugh has been appointed in Manaaki Whenua-Landcare Research as a Geomorphologist. He is working in the erosion and sediment processes area focusing on measuring and modelling erosion processes and using sediment fingerprinting techniques to quantify contributions from catchment sources to downstream sediments.

Andrew Neverman has joined the Soils & Landscapes team at Manaaki Whenua as a geomorphologist. Andrew is in the final stages of completing a PhD at Massey University where his research has focused on measuring gravel transport and substrate stability in rivers. His work at Manaaki Whenua will be focused on quantifying erosion at the event-scale and developing event-based erosion and sediment transport models. Andrew is also particularly interested in studying the relationships between sediment transport processes and freshwater ecological communities, and the application of UAV technology for catchment management.
PhD student, **Ahmed El-Naggar** with **Carolyn Hedley** attended the Irrigation New Zealand conference in Alexandra in April, and Ahmed gave a presentation on soil and crop sensors for precise irrigation scheduling. The conference was attended by close to 400 people, and we were told about the long history of irrigation in this region. Water races built into the hills in the 1800s by gold miners are still in operation today. The water provides essential irrigation and frost control for the valuable soft fruit industry of that region.

Our three pedometricians, **Pierre Roudier**, **Michael Blaschek** and **Matteo Poggio** attended the 18th ANISG - NZNIRSS Conference in Rotorua on 11 – 12th April, 2018. Matteo presented a talk on “Integrating visible near infra-red spectroscopy with a gamma-ray sensing platform for automated soil core scanning” and Michael Blaschek presented a talk on “Least-squares support vector machines and visible near infrared spectroscopy for predicting volumetric water content of New Zealand

soils." Matteo was awarded the Lynsey Welsh Award for innovation in Near Infrared Spectroscopy. This is the main award for the Australian Near Infrared Spectroscopy Group and Matteo is only the second person from a New Zealand institute to receive it, since its inception in 1998 – so congratulations to Matteo. Matteo has also been enjoying the New Zealand countryside as a member of our field teams collecting soil cores for assessing soil carbon stocks in hill country ([photo].

Correspondent: Carolyn Hedley hedleyc@landcareresearch.co.nz
Date: 15 May 2018

Massey University

Recent restructuring within the College of Sciences at Massey University has resulted in changes to the Soil & Earth Sciences Group which has been led by Professor **Mike Hedley** since 1997. From January 2018 we are now within the School of Agriculture & Environment which has been structured into five 'Groups':

1. Agriculture
2. Animal Science
3. Environmental Sciences
4. Wildlife & Ecology
5. Ag & Hort Enterprises (Massey Farms, Research Units, Orchard etc).

The Environmental Sciences Group is led by Professor **Chris Anderson** and incorporates Soil Science (and FLRC), Environmental Management, Precision Agriculture and Geosciences (Earth Science and Physical Geography). There is considerable effort going into remodelling some of our teaching programmes, but for the most part it is 'business as usual' as we pursue research interests and the delivery of Professional Development courses.

The main graduation ceremonies for Massey University were held in Palmerston North in May and the town was full of families celebrating academic achievements. PhD (Soil Science) was conferred on Aaron Stafford for his research thesis entitled 'Distribution of cadmium (Cd) in long-term dairy soils, its accumulation in selected plant species, and the implications for management and mitigation'. Aaron was supervised by Dr's Chris Anderson, Mike Hedley and **Jeya Paramsothy**

Dr Aaron Stafford (right) with Professor Mike Hedley

Glenys Wallace recently retired from Soil & Earth Sciences after more than 30 years supporting research and undergraduate/postgraduate students. Glenys was remembered at a retirement function as being a most highly skilled and dedicated technician who was always willing to go the extra mile to get the job done. She was a meticulous analyst and throughout the time when fluoride methodology was being researched, proved most capable getting reproducable results.

Recognising her as an excellent technician and very skilled analyst, Mike Hedley presented Glenys with a hat adorned with 'spikes' for each of the elements she had analysed as part of her job. He also spoke of her dedication, the role she played as 'Mum' to younger staff and students and the many extras she had in her role – such as proof-reading, recycling and attending to the needs of the common room. Glenys responded with some stories of her time throughout the years, the many friends she has made and the great variety of work in which she had played a part. She spoke with great fondness about the late Robert Brookes (Emeritus Professor) who was a most amusing character, in addition to being a brilliant scientist.

Glenys leaves a big hole in the 'Soil Science family' and we wish her well in her retirement.

Recent arrivals studying Soil Science at Massey include:

Chao Kong is a PhD student from China, funded by the Chinese Scholarship Council, who is doing is research on the mitigation of drought and salt stress in arid regions with the use of artificial soils (Technosols) at Massey University. Chao will also investigate the potential of low-cost technologies to eliminate salts from irrigation water. Special focus will be made to simulate conditions similar to those in the Western Sahara region. Chao has a MsC degree on Resources and Environment Remote Sensing obtained at the Institute of Soil Science of the Chinese Academy of Sciences in Nanjing.

Chao Kong is supervised by Marta Camps Arbestain, Qinhua Shen, Brent Clothier (Plant & Food Research), and Felipe Macias (Universidad de Santiago de Compostela).

Idri Hastuty is a PhD student from Indonesia who just started her PhD at Massey University funded by NZAid. She previously obtained a MSc degree from the University of Bonn (Germany). The aim of her PhD studies is to investigate the response of soil carbon pools in selected Taranaki volcanic soils to increasing temperature. Idri will quantify soil total C and C fractions (i.e., protected/unprotected C pools) in soils across a 5 °C mean annual temperature gradient in Taranaki. She will monitor temperature and moisture changes at paired field sites with/without canopy, then establish a glasshouse experiment.

The studies will also involve the chemical characterisation of organic matter using pyrolysis-GC/MS and that of the mineral fraction. Idri is also actively involved with the local Indonesian student community and helps provide information to prospective students wanting to pursue study in Massey University. Idri Hastuty is supervised by Marta Camps Arbestain, Qinhua Shen, Gabor Kereszturi and Miko Kirschbaum (Landcare Research).

Lili Ye, a PhD candidate, with a major degree in Environment Science and Engineering obtained at Guilin University and Technology, China, is doing a 6-month internship at the School of Agriculture and Environment (Massey University). During her stay she is working in a meta-analysis on "The Response of Crop Yield and Soil Nutrient Status to the Long Term Application of Biochar Amendment" under the guidance of Marta Camps-Arbestain and Qinhua Shen.

Canterbury

Scion (Rotorua/Christchurch)

Connecting soils and forested ecosystems, Scion recently hosted the annual Growing Confidence in Forestry's Future (GCFF) conference in Rotorua. A strong component of this MBIE program is understanding and managing soil resources in forestry estates. Improving the physical, nutritional, and biological quality of forest soils is fundamental to this. At the GCFF conference, forest owners and managers were encouraged to identify opportunities to improve soils from different sites. In order to demonstrate the potential for gains in forest productivity and sustainability, a series of 'Accelerator' trials have been set up around New Zealand. A visit to one of these sites, in the Kaingaroa forest, formed part of the conference field-trip. Delegates were introduced to the Accelerator trials, soil management opportunities, on ground and UAV soil mapping, through to soil biology and tree phytobiomes (see figure). A highlight of the site visit was a presentation by soil N-cycling scientist, Dr Amanda Matson (Scion), on the use of 15N labelled urea to monitor N movement through these porous soils. The presentation was delivered on top of a set of lysimeters recently installed at the site!

GCFF conference field trip to the Kaingaroa forest. (A) Dr Simeon Smaill discusses soils, Accelerator trials, and productive forest ecosystems; (B) a UAV used for LIDAR and other remote spectroscopy is demonstrated; (C) Dr Amanda Matson, above a set of lysimeters, talks N and nutrient flow in soils.

In Christchurch, we welcomed Mr Mathis Richard from AgroSup (Dijon, France) to the team. Mathis is undertaking an internship at Scion, focusing on identifying suitable biological metrics that can be incorporated into forest soil health/quality monitoring. Also joining the team in the near future is Dr Xiaoben Jiang. Xiaoben will be with Scion for 2 years, exploring how trees and other plants communicate with soil microorganisms and form their below and above-ground microbiomes (phytobiome). This work is supported by the BioProtection Research Centre, and is a collaboration between Scion, Lincoln University (Prof. Leo Condron) and AgResearch (Dr Maureen O'Callaghan).

The topic of 'soil and ecosystems' was hot on the agenda at a 'Soil-plant interactions' workshop at Huazhong Agricultural University (Wuhan, China) delivered by Scion scientists. The workshop covered aspects of plant nutrition, soil fertility, and management of resources in a changing world. A strong focus was climate change, population growth, and where we might obtain our food, fiber, and energy sources in 2050. The audience, a group of local students and researchers, took away a strong message that 'we need to plan our agricultural ecosystems to capitalize on future opportunities climate change will bring, and build resilience in ecosystems to future disturbances'. Talks and scenario planning were delivered by Dr Jainming Xue, Peter Clinton, Simeon Smaill, and Steve Wakelin (all Scion), and Prof A.K. Srivastava (ICAR, India). In addition to the workshop, visits and presentations on soils and sustainable agricultural production were given at Zhejiang University (Hangzhou), Shaoxing university (Zhejiang), and Wuhan University of Technology (Wuhan) (Wakelin and Xue).

Testing different crop responses to N, P, and K. A small plot, replicated trial at Wuhan University, China.

On May 8th and 9th, several Scion scientists gave presentations on a range of topics at the 2018 New Zealand Farm Forestry Association Conference; not surprisingly, soil featured heavily on the agenda! The audience of around 180 people took the opportunity to ask various questions about the science and how new knowledge and technologies could be implemented into the day-to-day management of soil resources in their farms, prompting much vigorous debate. Discussions included:

- The importance of understanding your soils to help match tree species to site;
- The role of forests in remediating nitrogen saturated soils and limiting nitrogen losses;
- The response of soils and the soil microbial community to different forest harvest techniques;
- The potential for UAVs and remote sensing to rapidly characterise soil properties;
- Opportunities to enhance beneficial activities of the soil microbial community.

The mixed land use systems of FFA necessitates that the farmers/landowners think at 'system level' when managing their operations. The forest needs to be in the right part of the landscape, for a defined purpose, and effects on total C budgets, water flow and quality, recreation, and other ecosystem services need to be considered. In some ways, this is the very thinking that is needed to support the Governments objective of '1 billion trees'. A good deal of soil science and ecosystem modelling will be needed to underpin putting the right tree, in the right place, for the right purpose.

Farm Forestry Association field trip, May 2018. Delegates considering all things soils, forests, land use, and maintaining profitable and sustainable productive land use that consider multiple ecosystem services. A good model for NZ inc and 1 Billion trees?
Team Scion

Lincoln University

The Department of Soil and Physical Sciences held their traditional graduation morning tea. This was an occasion to celebrate with the graduands from the Department and their families. Several family members commented that it was a wonderful opportunity to take part in celebrating graduation (especially if they were not able to attend the ceremony) and also to meet the staff and students at Lincoln.

Over 350 farmers turned out on **Lincoln University Dairy Farm** on Thursday, 4th May for the launch of a new technology developed by Lincoln University and Ravensdown. The Minister of Agriculture (Hon Damien O'Connor) launched the technology and Professor Bruce McKenzie spoke on behalf of Lincoln University. The technology, called ClearTech, treats farm dairy effluent in order to: (i) recycle water at the dairy shed, (ii) reduce the amount of effluent produced each day and (iii) decrease the environmental and health risks associated with effluent management.

The research project was led by **Professors Keith Cameron** and **Hong Di** with outstanding technical support from Carole Barlow, Roger Atkinson, Steve Moore and other members of the Soil & Physical Sciences Dept. If you would like to read more about it, or see the video clip of the treatment process, go to: https://www.cleartech.co.nz/

Photo kindly supplied by Dr Carol Smith

We welcome Dr. Rosalind (Ros) Dodd to the Department as our new lecturer in soil science. Ros comes to us from Bangor University, where she was the Sér Cymru Fellow in the School of Environment, Natural Resources and Geography. She was working with Prof. Davey Jones on the Climate Smart Grass research project, as part of the National Research Network for Low Carbon Energy and Environment. Prior to that, she worked as a Post Doc with Andrew Sharpley at the University of Arkansas, in Fayetteville. Many people will remember Ros as she did her PhD at Lincoln (based AgResearch, Invermay), with Leo Condron and Richard McDowell.

Ros is originally from the UK with a MChem from York and a MSc in Environmental Biogeochemistry from Newcastle; she is here with her husband, Ben. Ros will be teaching into PHSC101 and examining PHSC211.

New visiting postgrad students/ Researchers:
Welcome to PhD student **Xueying Wang** from the School of Earth and Space Sciences at the University of Science and Technology, Anhui, China. Xueying has received funding from Chinese Scholarship Council to spend 2 months at Lincoln

University from 17 May 2018, supervised by Prof Leo Condron and will investigate how different plant species mobilise various forms of soil phosphorus.

Florencia De Lucca Agrelo: Masters student from Universidad de la Republica de Uruguay will be here for 3 months under the supervision of Profs Condron and McDowell working on the nature and mobility of phosphorus in the environment.

Xiaodong Chen: PhD student from the Institute of Applied Ecology at the Chinese Academy of Sciences will be here for 12 months under the supervision of Prof Condron working on the impact of land use change on soil carbon and nutrient dynamics (in collaboration with Prof Dunfield, University of Guelph, Canada).

Yanting Mao: visiting scientist from Institute of Agricultural Environmental and Resources, Yunnan Academy of Agricultural Sciences is here for one year as part of the NZ China Water Research Collaboration Centre. Yanting is hosted by Dr Henry Chau and Prof. Hong Di.

In the news...

Major report: What we've done to NZ's landscape

Our Land 2018 was released in April and is the latest report in the environmental reporting series published by the Ministry for the Environment and Stats NZ. “The report makes it clear that we need to pay attention to what’s going on in our soil, which underpins our economy. It shows us where we need to focus,” Penny Nelson, Deputy Secretary at the Ministry for the Environment said.
Find the report, and associated information on MfE’s website.

New Zealand's land environment has been transformed - and dramatic changes have unfolded in just the past two decades. From NZ Herald.

Beef + Lamb New Zealand unveil new Environmental Strategy

The Environment Strategy lays out a progressive long-term vision for the sector based around four priority areas – healthy productive soils, thriving biodiversity, reducing carbon emissions and cleaner water.
Find the strategy and related info on the Beef + Lamb website.

New Zealand Journal of Agricultural Research Special Issue: **"Implications of grass-clover interactions in dairy pastures for forage value indexing systems"** (Volume 61/2). This Special Issue features guest editors Mike Dodd and Errol Thom of DairyNZ, and Cory Matthew of Massey University's School of Agriculture. This collection of papers discusses some of the interactions between maintaining dairy pastures and cattle, and indexing the processes involved in selecting certain grass cultivars.
Available now at Taylor and Francis Online

The farmer-less farms of the future

For the first time ever, a UK design team have grown and harvested a crop without a single human being setting foot in the field. From RNZ's This way up

Sensing slips: a Kiwi innovation in landslide detection

A team at Victoria University of Wellington hopes that a network of cheap GPS sensors could help us make accurate slip predictions at a fraction of the cost of a surveyor taking regular measurements with their instruments. From RNZ's This way up

Protecting soil could improve river health

A report by WWF, The Rivers Trust and The Angling Trust finds that only 14% of rivers in England are classed as healthy, with damage being caused by poor farming and land management practices, for example by degraded soil being washed into watercourses and agricultural chemicals contaminating groundwater.

Special feature

Pedological and some other soil-related activities within the Earth sciences discipline at the University of Waikato, Hamilton – the first 50 years (1969-2018)

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Citation:
Lowe, D.J., Balks, M.R. 2018. Pedological and some other soil-related activities within the Earth sciences discipline at the University of Waikato, Hamilton – the first 50 years (1969-2018). *New Zealand Soil News* 66 (2)

Abstract

We outline teaching and research activities relating to pedology and soil survey, and some other soil-related work involving geomechanics, both in New Zealand and Antarctica, carried out by staff and students in the Earth Sciences discipline at the University of Waikato for the 50-year period from 1969 to 2018. Key features include: (i) the insightful multi-disciplinary approach using a new Earth sciences' framework that was enacted at the outset by founding professor John D. McCraw and colleagues Michael J. Selby and Harry S. Gibbs in particular; (ii) the development of teaching and research strengths in pedology, especially involving tephra-derived soils and soil stratigraphy in the central North Island, and the concomitant advancement of prowessness in Quaternary tephrostratigraphy and tephrochronology; (iii) the development of expertise in slope studies and rock and soil mechanics (geomechanics, engineering geology), with specialist advancements regarding pyroclastic and associated reworked deposits and altered products; (iv) pathfinding research involving classical soil surveying and the subsequent growth of the use of GIS and geostatistical tools, which aided the eventual development of digital soil mapping beyond the university, and their application to a wide range of disciplines including geomorphology, sustainable plantation forestry, agriculture, and horticulture; (v) growth of expertise in multiple aspects of studies on wetlands (peatlands, lakes), and in environmental and carbon- and nitrogen-flux based research; (vi) pioneering and enduring research in Antarctica including soil surveying and studies on human impacts; and (vii) the successful development of an effective postgraduate school encompassing pedology, soil science, and geomechanics (amongst other disciplines). Waikato students have received around one half of the New Zealand Society of Soil Science annual awards for 'best masterate thesis', and around one third for 'best doctoral thesis' since 1976. In addition, staff and students in the department have led or contributed to many regional, national, and international conferences and associated field trips involving soils or Earth sciences, to the development of the "New Zealand Soil Classification", and to the discipline of pedology in many other ways including serving as editors and in professional societies.

1. Introduction

In this article, written in part to support a wider review being undertaken by Dr Philip Tonkin to synthesise the history of soil survey and selected aspects of soil conservation in New Zealand, we provide a short historical outline of the background and development of aspects of teaching and research activities relating to pedology and soil survey, and some other soil-related work including geomechanics, both in New Zealand and Antarctica, in the Earth Sciences discipline at the University of Waikato from 1969 to 2018. Of course, we provide a personal and selective view – we could not hope to cover every topic for the 50-year period, but numerous references should help to provide a flavour of the hard-won contributions and outcomes of the efforts by both staff and students. We acknowledge the great support received from technical and administrative staff that enabled the staff and students to undertake their research and other activities. We conclude by summarising some of the main features that may be seen to characterise the history.

2. Developing the new discipline of Earth sciences

The Department of Earth Sciences at the University of Waikato was established in 1970 within the newly-formed School of Science (Earth Sciences Staff, 1987; Nelson, 2000; Lowe, 2002a). Dr John McCraw, the foundation professor, and Michael J. Selby, senior lecturer, were both appointed in 1969 to enable them to prepare for the first student enrolments in 1970. John and Michael, soon to be joined by Harry Gibbs in 1970, played pivotal roles in the initial development of the department using a unique, integrative multi-disciplinary approach (Fig. 1). From 2006 the department operated as the Department of Earth and Ocean Sciences until April 2014. Then the subject 'Earth Sciences' became one of three alongside 'Biological Sciences' and 'Chemistry' within a revamped School of Science that continues today (Nelson et al., 2015).

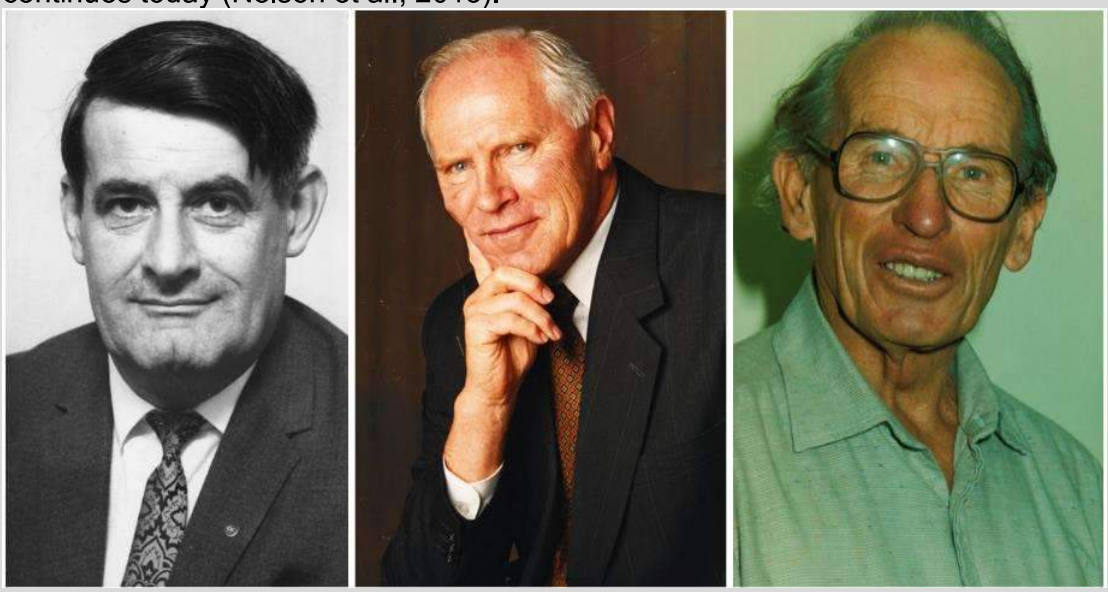

Fig. 1. From left, Professors John McCraw (in 1969), Michael Selby, and Harry Gibbs, the 'big three' who effectively founded the Department of Earth Sciences 1969-1970. Photos: University of Waikato.

Professor John McCraw, although trained as a geologist at the University of Otago, had spent the previous two decades as a pedologist and soil surveyor with the Soil Bureau of the New Zealand Department of Scientific and Industrial Research (DSIR). In this role he undertook pioneering work in Central Otago (e.g., McCraw, 1956,

1959, 1962, 1964, 1968) and then carried out the first soil survey of the Taylor Valley in the Dry Valleys area of the Ross Dependency, Antarctica (McCraw 1967a, 1967b). John later developed a life-long interest in the Hamilton Basin and its demonstrative soil-landscape relationships (e.g., McCraw, 1967c), and he returned to this topic (among many others) in his retirement years (e.g., McCraw, 2002a, 2011). A notable role undertaken by John McCraw in the late 1970s whilst head of department was his participation in the enquiry into the Abbotsford landslip disaster (Gallen et al., 1980). Professor McCraw retired in early 1988. Further details of his career and impact are provided by Nelson et al. (2015) and Tonkin et al. (2015).

In establishing the department, John had the assistance initially of Michael Selby, and then of Harry Gibbs, formerly the Chief Pedologist in Soil Bureau. Not surprisingly, pedology and geomorphology were included together with other core geoscience subjects in the early undergraduate and post-graduate Earth sciences' curriculum (McCraw, 2002b).

A geographer/geomorphologist trained at Oxford University, Michael, after teaching at Christ's College in Christchurch from 1960, was appointed a lecturer in physical geography in 1964 at the Waikato Branch of the University of Auckland in Hamilton. He then transferred to geography in the new University of Waikato in 1965 (the university having been founded in February 1964: Acorn, 2014) before being appointed to the new Department of Earth Sciences (1969). Michael wrote or edited seven text books, the first two being published in 1967 and 1971 (Selby, 1967a, 1971a), and a number of papers early on, thereby helping to establish the department's reputation and credibility in surface Earth sciences. In addition, Michael edited Earth Science Journal, based in Hamilton, for five years (1967-1971). He retired in 2002 as Deputy Vice Chancellor of the University of Waikato. Michael's career and legacy are reviewed by Nelson (2018).

As well as teaching (Fig. 2), a role to which he was well-suited, Harry Gibbs mentored and supervised a cohort of the earliest graduates undertaking pedology-based masterate research, and he wrote articles mainly about soils and land use (e.g., Gibbs, 1971a, 1974, 1981, 1982, 1983). Harry also published some of the soil survey work he had carried out largely prior to his appointment at Waikato (e.g., Gibbs, 1976; Northey and Gibbs, 1976), as did John McCraw (McCraw, 1974; McCraw and Bell, 1975). Professor Harry Gibbs retired in 1979, publishing an introductory textbook on New Zealand soils at around the same time (Gibbs, 1980).

Fig. 2. Harry Gibbs (far right) in his element with undergraduate students in the field looking at soils in the landscape (possibly at Hopuhopu Military Camp near Ngaruawahia) in c. 1973. Photo: R.R. Julian.

A distinctive character of the School of Science is the continuing Antarctic research programme that was initiated in the 1969-1970 field season with a party comprising Professor Alex T. Wilson (foundation professor of Chemistry and Dean of the School of Science), Michael Selby, Chris Hendy (Chris, working at DSIR at the time, was later appointed to a lectureship in chemistry at Waikato in 1971), and Jim Johnson (PhD student) (Harrowfield, 2007). Further details of the more recent Antarctic research programme relating to soil survey and associated studies are given below in section 10.

3. Pedology

The pedological capability of the department was enhanced with the appointments of Robert (Bob) F. Allbrook in 1975, David J. Lowe in 1979 (initially for 2.5 years, then continuously from 1984), Vicki G. Moon in 1984, Richard Chapman in 1986, and Megan R. Balks in 1988.

Dr Bob Allbrook was a graduate of Newcastle on Tyne University, and had spent a period as a soil surveyor in Nigeria before completing his doctorate (finalized after his appointment to the department) at the University of Malaya, where he studied the genesis of rice soils. His research at Waikato was mainly in the field of soil physics and included studies on the special properties of allophane and allophanic soils (Allbrook, 1983, 1985), and soil compaction and shrinkage (e.g., Cotching et al., 1979; Allbrook, 1980, 1986, 1992; Fredricksen, 1988; McLay et al., 1992). Bob, who retired in 1993, also was interested in the history of soil science in New Zealand (Allbrook, 1990, 1997) (Fig. 3).

Fig. 3. Staff of the Department of Earth Sciences, including Bob Allbrook (far left, second row) in 1987. Photo: University of Waikato.

Dr David Lowe (now professor) is a graduate of the University of Waikato where he teaches pedology and tephrochronology among his many interests that include soils derived from volcanic-ash (tephra), geochronology, Quaternary climate change, and geoarchaeology. Prior to his doctoral studies, David had short stints with Soil Bureau (Hamilton office), working on the Matamata County survey under the supervision of Gary Orbell, and preparing benzene in vacuum lines of the fledgling Waikato Radiocarbon Dating Laboratory within the Department of Chemistry. Dr Megan Balks, a graduate of Massey and Waikato universities, was a contract employee with Soil Bureau on soil surveys in Central Otago before moving to Waikato.

Pedology is included within the mix of undergraduate training together with other subjects relevant to teaching and research in soil geomorphology, Quaternary stratigraphy and chronology, soil and rock mechanics, and engineering geology. Numerous post-graduate studies have included aspects of pedology and soil survey amidst geological, environmental and palaeoecological focusses. In recent decades, a resource and environmental planning programme at Waikato was developed in conjunction with staff of the Department of Geography in the Faculty of Arts and Social Sciences. Dr Megan Balks developed and led the environmental sciences teaching curriculum for many years. Dr Vicki Moon teaches slope stability and engineering geology including geomorphology, this last subject becoming incorporated into a new GIS-based paper on spatial analysis in the Earth sciences, one of five year-2 level papers on offer in Earth sciences within a new curriculum that was executed from 2018 right across the university.

Dr Chris McLay, appointed to replace Bob Allbrook in 1994, taught soil science until he went to the Waikato Regional Council in 2002. Dr Louis Schipper (soil microbiology, carbon and nitrogen in soil-landscape systems) was appointed in 2005 and continues (as professor) in the Earth sciences programme today, working

closely with Associate Professor David Campbell (ecohydrology and climatology, especially of wetlands: section 9), and others, undertaking research in carbon fluxes and nutrient cycling, denitrification and nitrogen immobilisation, impacts of land use change, and microbial ecology, at scales ranging from molecular to landscape to global (e.g., Schipper et al., 2007, 2012, 2014a, 2014b, 2017).

Since the 1970s, numerous students have undertaken pedology-based thesis projects but the first to focus on soil survey per se was probably Dr Peter Singleton (Singleton, 1981), who later went on to write the seminal Ruakura soils bulletin, "A Window on the Waikato" (Singleton, 1991). Large-scale soil maps include those generated by former students Sarah Stiles (1998) and Kathryn McLauchlan (2001). Kathryn's work at her field site, located just north of Te Awamutu, followed, in a small way, in the footsteps of the influential soil survey of Waipa County undertaken by Grange et al. (1939), the first in New Zealand to use purpose-flown aerial photographs for soil mapping.

David Lowe carried out his first contract research, namely mapping soils on Steele's Farm at a scale of 1: 1250 near Hamilton Airport (Fig. 4; Lowe, 1979). The survey was commissioned by Bruce Willoughby who was leading a research programme at the Ministry of Agriculture and Fisheries, Hamilton, into grass grubs (brown beetle larvae, Costelytra zealandica). Bruce wanted to evaluate the effects of soil type on the occurrence and effectiveness of various treatments (e.g., East and Willoughby, 1980). David and some other graduates in the department provided occasional labour for Bruce by taking large numbers of ~15-cm-long cores (~10 cm diameter) of surface soil horizons in various parts of the central North Island from which counts of 'grubs' were then made.

Meanwhile, Tara Pryce mapped soils from both pedological and engineering viewpoints in her masterate thesis in the Flagstaff area of north Hamilton that was being developed for city expansion (Pryce, 1997), discovering a drained lake bed in the process. Richard Chapman examined soils on basaltic materials in the Raglan area with respect to cobalt levels and agriculture (Chapman, 1983), and later wrote a PhD thesis on soil physics (Chapman, 1992). Richard's PhD, interestingly, involved subsoiling trials on the physical properties of soils at Rugby Park (now Waikato Stadium), Hamilton, in preparation for the internationals held there during the Rugby World Cup of 1987 (Chapman and Allbrook, 1987).

The masterate study carried out by Warwick McDonald on pedality (soil structure) under pines and pasture (McDonald, 1985) led him eventually to high-level management roles involving soil and water resources, both in New Zealand and Australia, where he is currently director of CSIRO's Land and Water Research Management Program.

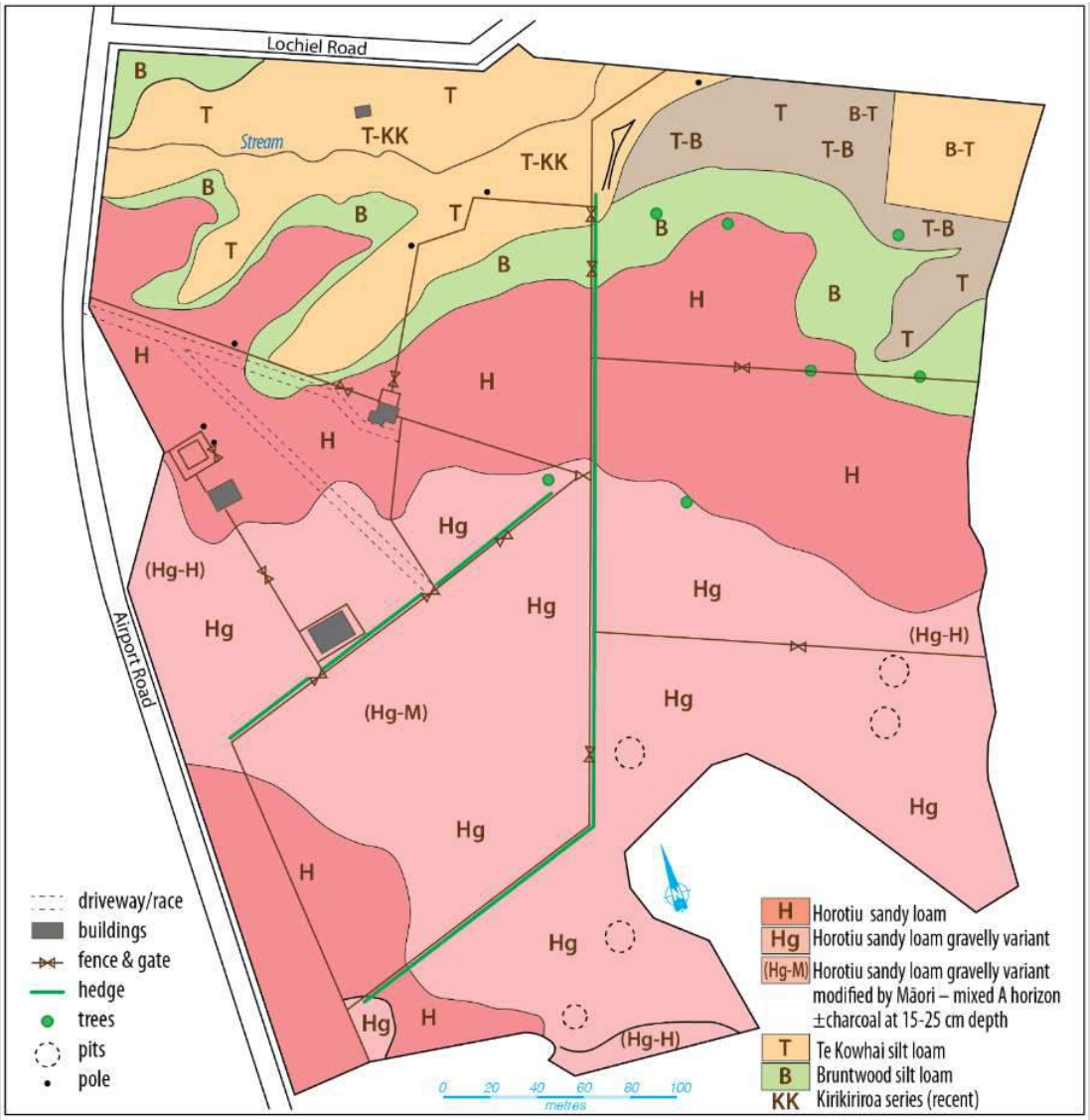

Fig. 4. Soil map made by David Lowe of Steele Farm, adjacent to Airport and Lochiel roads, Hamilton, originally at 1: 1250 (redrawn from Lowe, 1979, by cartographer Max Oulton).

5. Tephra studies and tephra-derived soils

David Lowe mapped distal tephra deposits in peat bogs and lake sediments, including the detection of what are now called cryptotephras (sparse glass shard and/or crystal concentrations preserved and 'hidden' in sediments or soils but insufficiently numerous, or too fine-grained, to be visible as a layer to the naked eye: Lowe, 2011) as part of his PhD research (Lowe et al., 1981; Lowe, 1985, 1988a, 1988b). Harry Gibbs and John McCraw, themselves building on the work of pioneers Les Grange, Norman Taylor, Colin Vucetich, and Alan Pullar (e.g., Grange, 1931; Taylor, 1932; Vucetich and Pullar, 1964; Pullar, 1967; see also reviews by Lowe, 1990a; Lowe et al., 2008a), had led the way with noteworthy papers involving tephras and tephra-derived soils (Gibbs, 1968, 1971b; McCraw and Whitton, 1971; McCraw, 1975). But David followed perhaps more closely in the footsteps of Victoria University of Wellington graduate and geochemist, Dr Peter Hodder, and Waikato graduate, Dr Alan Hogg, in adopting laboratory-based mineralogical and geochemical techniques to supplement field observations. Peter Hodder

investigated the origins of composite tephra-derived soils formed on the so-called "Tirau and Mairoa ashes" (Gibbs et al., 1982; Hodder and Wilson, 1976; Lowe, 1988a) in the Waikato region for his DPhil thesis at Waikato University, only the second awarded in the department (Hodder, 1974). Dr Hodder, a staff member in the department from 1980 until 1999, taught mainly geochemistry as well as environmental science and aspects of science history and philosophy. In the late 1970s, Dr Alan Hogg, now director of the Waikato Radiocarbon Dating Laboratory, investigated tephras and their distribution on the Coromandel Peninsula for his PhD (Hogg, 1979; Hogg and McCraw, 1983). Earlier he, along with Dr Tony Davoren, Ray Salter, Graham Shepherd, and Dr Joanne Horrocks, worked on the strongly weathered Kauroa and Hamilton ash sequences (Hogg, 1974; Davoren, 1976; Salter, 1979; Shepherd, 1984; Horrocks, 2000; see also Lowe et al., 2001). John Fry also undertook early studies on tephras (Fry, 1976).

The early work on tephras by David Lowe led him and colleagues and students to deeper research about the distribution, stratigraphy, nature (especially the unique clay mineralogy), and genesis of tephra-derived soils and paleosols in the North Island and also South Australia (e.g., Lowe, 1981, 1986, 1995; Hodder et al., 1990; Lowe and Nelson, 1983; Lowe and Green, 1992; Lowe and Percival, 1993; Lowe and Palmer, 2005; Takesako et al., 2010; Churchman and Lowe, 2012; McDaniel et al., 2012; Huang et al., 2016a, 2016b; Taylor et al., 2016). A foray into the powerful world of micromorphology with Lideweij (Liddy) Bakker, enrolled at Wageningen University and supervised by Dr Toine Jongmans, led to a publication on the development of properties of an age sequence of soils developed on tephra as seen through the microscope (Bakker et al., 1996a). That work by Liddy was presented at an international field conference on "Tephra, Loess, and Paleosols" organised by David Lowe on behalf of the International Union for Quaternary Research (INQUA) at the University of Waikato in February, 1994 (Lowe, 1996). The meeting was the first to be held involving three disciplines under the aegis of INQUA, and included two one-day regional field trips and a five-day post-conference field trip through North Island (Lowe, 1994). Liddy Bakker then embarked on her PhD project at Waikato on landscape evolution, which is described in section 8.

Many aspects of the understanding gained, including soil stratigraphy-based models for upbuilding pedogenesis (Lowe and Tonkin, 2010; Lowe et al., 2015), have been reported in North Island-based field trip guides associated with a series of national and international soil conferences since 2006 involving input from David Lowe and others (e.g., Lowe, 2006, 2008, 2010, 2016; Lowe et al., 2010, 2012, 2014) (Fig. 5). Nadia Laubscher (2014) undertook an exceptionally interesting MSc thesis project by investigating the exhumation of buried paleosols on Holocene tephras ("flipped soils") in the Galatea region of eastern Bay of Plenty that featured in the field trip documented by Lowe et al. (2014) (Fig. 6).

Fig. 5. Spectacular sequence of tephras and buried soil horizons at Eric Smeiths' quarry near the Whirinaki River, Murupara, in October 2014 prior to the group visit during the "Hot Volcanic Soils" field trip (Fig. 6). All the tephras except Taupo are from the Okataina Volcanic Centre; ages are from Lowe et al. (2013). Fluvial deposits (pebbles, cobbles) almost certainly underlie the Waiohau tephra (not visible). The modern Galatea soil, with Kaharoa tephra (deposited AD 1314 ± 12: Hogg et al., 2003) at the surface, is an Immature Orthic Pumice Soil, tephric, with pumice clasts > 2 mm ("rhyolite stones"), sandy, rapid (Hewitt, 2010; Webb and Lilburne, 2011). In "Soil Taxonomy" it is a Typic Udivitrand, pumiceous, glassy, mesic (Soil Survey Staff, 2014) (Lowe et al., 2014). Photo: D.J. Lowe.

Fig. 6. Participants on the "Hot Volcanic Soils" field trip led by David Lowe, Megan Balks, and Nadia Laubscher, on Eric Smeith's farm on Whirinaki Road near Murupara, eastern Bay of Plenty, on 2 December, 2014. The trip to Taupo and the Galatea depression was run as part of the NZSSS national soils conference held in Hamilton from 1-4 December that year. Photo: D.J. Lowe.

In conjunction with tephra work, Joanne Macky (1997) and then Kerri Lanigan (2012) mapped subsurface tephric loess in the Tapapa-Tauranga and Rotorua areas, respectively, for their masterate theses. Previously, Glenn Wigley mapped in the Te Puke lowlands and used tephrochronology to date dunes, peats, and associated soils (Wigley, 1990; Lowe et al., 1992).

David Lowe, Alan Hogg and others also worked on the characterisation and dating of widespread tephras, which helped provide useful marker beds or isochrons for soil-related studies, for Quaternary paleoenvironmental studies, and for volcanological, archaeological, and historical research in New Zealand and elsewhere (e.g., Hogg et al., 1987, 2003, 2012; Lowe, 1988b, 1990a; Lowe et al., 1998, 2000, 2008b, 2011, 2013, 2017a; Newnham et al., 1998, 1999, 2018; Lane et al., 2017). David worked with Warren Gumbley and others on soils that had been modified by early Maori in the Waikato region to grow kumara (Gumbley et al., 2004) (see also Fig. 16 below), an interest shared by John McCraw (McCraw, 2011), and on the impact of volcanism on early Maori (Lowe et al., 2002).

6. New Zealand Soil Classification

David Lowe and Megan Balks, together with Bob Allbrook in the late 1980s-early 1990s, contributed to the development of the "New Zealand Soil Classification" (NZSC) system during its construction by Dr Allan Hewitt and publication of the first edition (1992a, 1992b, 1993) (NZSC is now in its third edition: Hewitt, 2010). They tested early versions of NZSC (e.g., Hewitt, 1987) and also aspects of the "Soil Description Handbook" (Milne et al., 1995), on pedology field trips with students

including during annual Northland and Waikato excursions (Fig. 7), and provided feedback to authors that did result in some improvements. Lowe and Allbrook also contributed to discussions on defining soil series (Allbrook, 1989; Clayden et al., 1989; Lowe, 1989). Reviews of NZSC and companion publications relating to soil survey (Clayden and Hewitt, 1989; Milne et al., 1995) were published by Lowe (1990b, 1992) and Lowe and Balks (1996).

Fig. 7. Dr Haydon Jones commenting on the properties of the photogenic Whangaripo soil (Mottled Yellow Ultic Soil in NZSC or Typic Hapludult in "Soil Taxonomy"), complete with red-weathered lower subsoil, near Warkworth, Northand, during a third-year pedology field trip in 2006.

7. Geomechanics and slope stability

Michael Selby initially examined slopes and landslides on the ash-mantled greywacke hills in the Whitehall area near Cambridge. In one of his earliest papers, he argued that non-periodic mass movement, rather than stream erosion as invoked by Sir Charles Cotton, was largely responsible for the origin of the slopes and boulder fields in the area (Selby 1966, 1967b). Moreover, Michael pointed out that some of the mass movement (such as landsliding) could be dated approximately using the presence of tephra deposits in or on the deposits, i.e., using tephrochronology, a method he employed in later studies with tephra 'guru', Dr Alan

Pullar (Pullar and Selby, 1971; Selby et al., 1971). Michael then worked on the erosion of pumice soils in the Taupo region in a characteristically innovative mix of specially designed field and laboratory experiments and (at the time) novel computer-based factor analysis (e.g., Selby, 1970a, 1970b, 1972, 1973; Selby and Hosking, 1971, 1973). Michael's DPhil thesis (Selby, 1971b) was the first to be completed in the Department of Earth Sciences and one of the first three doctorates to be awarded by the University of Waikato on 2 March 1972 (Nelson, 2018). Michael supervised Robin Palmer's masterate thesis on variations in soils on slopes at Whatawhata where ash overlies weathered greywacke (Palmer, 1974). Robin went to Massey University, where he mapped the soils of Egmont and part Taranaki counties 1975-1977 (Palmer et al., 1981), and then on to Soil Bureau.

With Dr Vicki Moon, Michael Selby developed soil and rock geomechanics, and subsequently an engineering geology programme, which potentially could expand with the advent of civil engineering in the Faculty of Science and Engineering from 2017. Engineering geology became an important strength within the Department of Earth Sciences from the 1980s-1990s, leading to many students subsequently gaining livelihoods in the field following masterate thesis projects in the discipline. Michael developed simple portable equipment to assess the mass strength of rocks and, from this and a number of other easily assessed parameters, he established a 'Rock Mass Strength Index' that has been adopted internationally, not only by geologists and geomorphologists, but also by engineers (Selby, 1980, 1982). The second edition of Michael's textbook "Hillslope Materials and Processes" (Selby 1993), which brilliantly integrates geomorphology with engineering geology, was named in 2005 as one of the 10 'classic' books of geomorphology and its author as one of the 20 most-cited geomorphologists in the English language (Doyle and Julian, 2005). Another book, "Landforms of New Zealand" (Soons and Selby, 1992), comprised the first synthesis of New Zealand geomorphology and landscapes since the seminal volumes of Sir Charles Cotton of the early- to middle-20th Century (e.g., Cotton, 1942) and has only recently been superseded in part by books published by Shulmeister (2017) and Williams (2017).

Vicki Moon has continued to lead research into mass movement and slope stability including landsliding and the role of sensitivity, especially in pyroclastic (tephra) deposits and their reworked and weathered derivatives (such as occur in the Tauranga area), mainly in northern North Island (e.g., Moon et al., 2015a, 2015b, 2017; Kluger et al., 2017; Robertson et al., 2017) (Fig. 8). These and associated studies on the impact of mass movement on forestry and farming (e.g., Heaphy et al., 2014; Noyes et al., 2015), and unexpected discoveries along the way (e.g., Cunningham et al., 2016; Lowe and Churchman, 2016), have been important topics for research over the past few decades at Waikato.

Fig. 8. Landslide at McDonnell Street in Omokoroa, Tauranga, close to the well-studied Bramley Drive landslide (e.g., see Moon et al., 2015b; Kluger et al., 2017). The McDonnel Street slide took place overnight 5-6 April, 2017, during the tail end of Cyclone Debbie. The Bramley Drive slide occurred on 9 August 1979 and was reactivated in May 2011 and in April and August 2012. Photo: V.G. Moon

With the discovery of numerous faults in the Hamilton area in 2015 (Moon and de Lange, 2017; Spinardi et al., 2017), the subject of paleoliquefaction is being investigated at present (e.g., Kleyburg et al., 2015; McKay et al., 2017).

8. GIS and pedometrics

The advent of geographic information systems (GIS) led to new work by Dr Lideweij Bakker on the Mamaku Plateau that involved developing a landform classification using a digital elevation model (Bakker et al., 1996b), and processes associated with the development of welded ignimbritic landscapes (Bakker, 1997) pertaining to the nine-unit landsurface model that was originally developed in the central Waikato region by Dalrymple et al. (1968). At around the same time, soil-landscape modelling was taking off (e.g., Webb, 1994) and two students, Dr Haydon Jones and Dr David Palmer, embarked on projects involving GIS and soil-landscape modelling at a range of scales relating primarily to requirements for plantation forestry. Scion staff, including Dr Tim Payn, Dr Mark Kimberley, and Barbara Höck, were key players in helping to support this research. Haydon Jones initially worked in Southland, aided greatly by Dr Ron Taskey (California Polytechnic State University), to develop a soil-landscape model using a land systems approach and to predict soil property variability in the Longwood Forest (a contract for Rayonier) (Jones et al., 1997; Jones, 1998). Haydon then switched to Northland to undertake his PhD work on developing soil-landscape models for the southern Mahurangi Forest near

Warkworth that additionally included a study to evaluate the impact of forest harvesting on the efficacy of the modelling to predict key soil properties (Jones et al., 2000; Jones, 2004). Haydon's field work in Northland was supported in part by Wim Rijkse (Landcare Research; see Lowe et al., 2017b) and Dr Toine Jongmans (Wageningen University).

David Palmer worked initially on Tihoi soils (Podzol Soils) on the Mamaku Plateau to evaluate their ability to sustain long-term radiata pine productivity, and he undertook spatial analysis using geostatistics (pedometrics) to compare soils under native forest with those under one and two pine rotations (Palmer et al., 2005) (Fig. 9). David then carried out his PhD project on spatial modelling of radiata pine productivity at the national extent, integrating multiple terrain attributes and surfaces, water-balance models, and soil and other data in macro-catchments across North and South islands and related them to pine-tree growth and its drivers (Palmer, 2008; Palmer et al., 2009a, 2009b, 2009c, 2010; Watt et al., 2010).

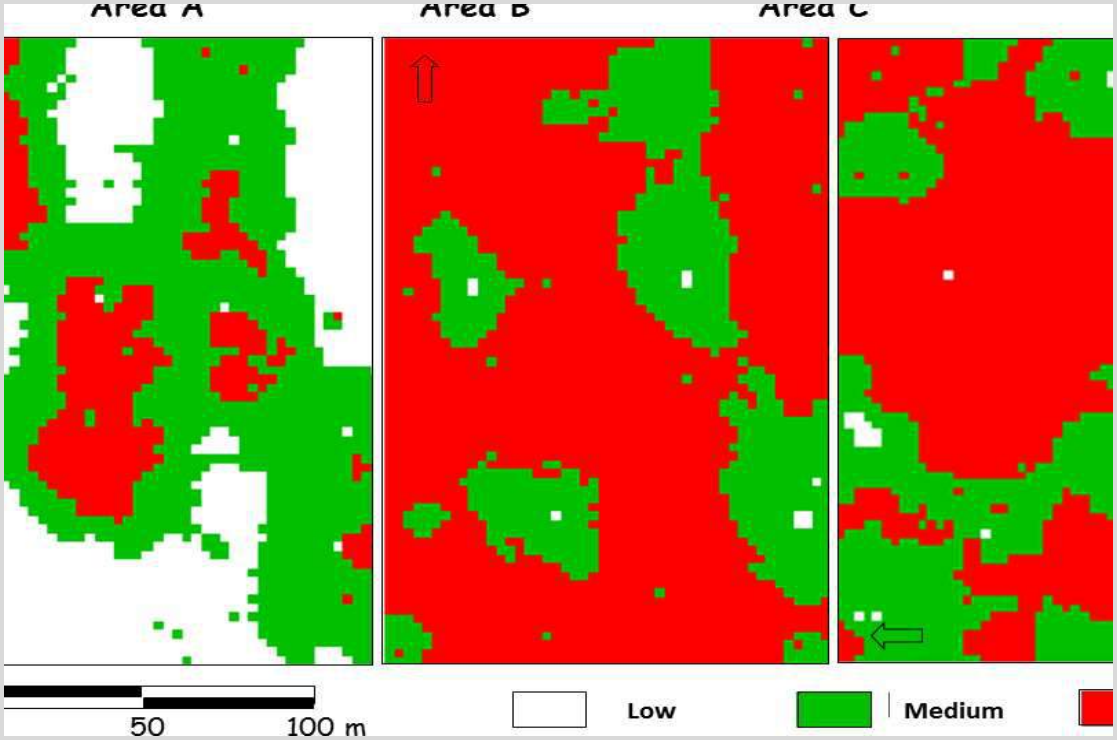

Fig. 9. Maps of P 'releasing capacity' of Tihoi soils (Humose Orthic Podzol Soils in NZSC or Andic Haplohumods in "Soil Taxonomy") on ~1800-year old Taupo ignimbrite (soft pumice) deposited AD 232 ± 10 (Hogg et al., 2012) at three sites on Mamaku Plateau (~10 km east of Tokoroa) with different forest histories: ***Area A***, Tihoi soils in original state under native forest; ***Area B***, Tihoi soils growing their first crop of *Pinus radiata* (24 years' growth in 2001 at the time of sampling); and ***Area C***, Tihoi soils that had grown one harvested crop of *P. radiata* and currently growing a second crop of radiata (4 years' growth in year 2001). The maps were derived by inverse-distance weighting as part of a pedometric project undertaken by David Palmer for his masterate thesis (from Palmer et al., 2005, p. 150).

More recently, Sharn Hainsworth undertook a mapping project for his masterate thesis involving both classical and digital soil mapping and land use capability (LUC) surveys on the Ruataniwha Plains in Hawke's Bay (Hainsworth, 2012). He is refining and developing further digital mapping techniques for hilly terrrains whilst working

for Landcare Research. James Linehan (2015) contributed to this research, employing soil-landscape modelling to map the greywacke foothills of southern Hawke's Bay. Sharn Hainsworth, Dr Malcom McLeod, and a number of other former Waikato students including Dr Scott Fraser, Dr David Palmer (until early 2017), Nadia Laubscher (from 2017), and Jonno Rau (from 2018) are engaged, or have been engaged, in Landcare Research's "Smap" soil survey programme.

9. Peatlands and peat lakes

Waikato University carried out a national survey of peat resources for the National Water and Soil Conservation Authority in 1975. This survey, coordinated by John McCraw, was led by Dr Tony Davoren (a Waikato MSc graduate) and was carried out by staff and students of the Earth Sciences and Biological Sciences departments (Davoren, 1978). Many detailed peatland-based research studies, especially on the large, unaltered restiad bog in the Hauraki lowlands, Kopouatai bog, and on Moanatuatua bog and the Waikato peat lakes, have since been carried out over the past 40 years by staff and students in the Earth sciences and other disciplines. Their research includes collaborative work on vegetation (present and past), stratigraphy (including tephrostratigraphy), palaeoenvironmental reconstructions (from palynology and plant macrofossils), ecohydrological functioning, and carbon exchange (e.g., Green and Lowe, 1985; Lowe and Hogg, 1986; Newnham et al., 1989, 1995; de Lange and Lowe, 1990; Hodder et al., 1991; Campbell et al., 1997; de Lange et al., 1999; Lowe et al., 1999; Thompson et al., 1999; Newnham and Lowe, 2000; Clarkson et al., 2004, 2009; Nieveen and Schipper, 2005; Gehrels et al., 2006, 2008; Goodrich et al., 2015, 2017). Degradation and shrinkage (subsidence) of peatlands through time have also been investigated (e.g., Pronger et al., 2014), along with their potential restoration (e.g., Clarkson et al., 1999).

One of the so-called peat lakes in the central Waikato region, Lake Maratoto, lies about 10 km south of Hamilton and is c. 22,000 years old (Fig. 10). The formalised boundary between the Pleistocene and the Holocene, defined in a Greenland ice core, is defined for Australasia in the sediments of Lake Maratoto (Walker et al., 2009), marked by a thin but distinctive Egmont-derived tephra layer, Konini bed-b, dated at c. 11,800 years old. The proposal for the tephra-bearing Lake Maratoto sediments to become the archive for the Australasian parastratotype for the base of the Holocene was made by Professor Rewi Newnham (Victoria University of Wellington) and David Lowe. Barrell et al. (2013) further suggested that the upper sediments of the lake provide a prospective New Zealand type section for the Holocene interglacial in New Zealand. Earlier, Lowe (1985, 1988a) and Green and Lowe (1985) used ground-penetrating radar, and multiple cores from the lake and adjacent peats, to map tephra layers in the peat and lacustrine deposits in and around Maratoto.

Fig. 10. Internationally important Lake Maratoto near Hamilton in which the Pleistocene-Holocene boundary for Australasia is defined as one of five global auxiliary sites (parastratotypes) for this transition. The lake is hemmed in to the west (top of image) by thick peat of the Rukuhia bog on top of volcanogenic alluvium (Hinuera Formation) (Green and Lowe, 1985). Photo: D.J. Lowe.

10. Soil survey in the Ross Dependency (Ross Sea region) of Antarctica

Prof John McCraw (along with Dr Graeme Claridge) undertook the first soil-focussed expedition to Antarctica in 1959-60 (commemorated 50 years later with a special anniversary event in the department, organised by Megan Balks, in November, 2009: Fig. 11). This trip resulted in the first soil mapping in Antarctica (noted earlier) with John's pioneering soil map of the Taylor Valley published in 1967 (McCraw, 1967a, 1967b). About ten years later, Michael Selby together with Peter Kamp, David Lowe, and Craig Law, undertook a sledging expedition to the Darwin Mountains area in the 1978-79 field season (Fig. 12). This trip was the first from Waikato to venture onto ice and beyond the 'tropical' Dry Valleys region. As well as mapping the hard-rock geology, Peter and David also mapped glacial deposits in the northern Britannia Range and correlated these with equivalent units in the Dry Valleys, thereby providing approximate ages for the moraines and soils exposed on them in the northern Britannia Range area (Kamp and Lowe, 1982). The discovery of the Derrick Peak iron meteorites (Clarke, 1982) was a highlight of the trip, and the party also had the honour of naming McCraw Glacier and Mount Selby in the mapping area to commemorate the leadership and contributions to Earth sciences of these two founding staff in the School of Science at the University of Waikato.

Fig. 11. John McCraw (left) and Graeme Claridge in November, 2009, at the University of Waikato's 50th anniversary celebration of their pioneering soil surveying trip to Antarctica in 1959-60. Photo: D.J. Lowe.

Fig. 12. Waikato University's field party on Darwin Glacier in November, 1978, before being lifted into the northern Britannia Range. From left, Peter Kamp, Craig Law, Michael Selby, and David Lowe. Photo: D.J. Lowe.

Building on the extensive Antarctic soil work of Drs Iain Campbell and Graeme Claridge (both Soil Bureau, DSIR), Dr Megan Balks led the next efforts to undertake soil mapping of Antarctica which were undertaken in collaboration with Landcare Research as part of a global initiative with the ANTPAS (Antarctic Permafrost and Soil) group. The major outcomes of this work were the detailed mapping of the Wright Valley undertaken by Malcolm McLeod for his PhD (McLeod et al., 2008, 2009; McLeod, 2012). A detailed map of the Cape Hallett area was undertaken by Erica Hofstee as an MSc project (Hofstee, 2006; Hofstee et al., 2006a). Three 'windows' in the deep south Beardmore Glacier area were mapped by Josh Scarrow as part of his MSc thesis (Scarrow, 2013; Scarrow et al., 2014), and a composite overall map of the wider region was developed by McLeod, Balks, and American colleague Prof James Bockheim (University of Wisconsin – Madison) (Balks et al., 2008) as well as an elucidation of the soil-landscape relationships (Balks et al., 2013; Balks and O'Neill, 2016). In addition, Bockheim and Balks (2008) edited a special Antarctic issue of *Geoderma*. A long-term soil climate monitoring programme, established in 1999, has provided the best available data in Antarctica related to depth of permafrost and between-season variability in Antarctic soil climate. The research on the data was undertaken by a series of MSc students (Wall, 2004; Adlam, 2009; Adlam et al., 2010; Seybold et al., 2010; Goddard 2013; Guglielmin et al., 2011; A. Carshalton, in progress). The active layer monitoring is also part of wider global permafrost monitoring efforts (e.g., Viera et al., 2010).

A major theme of much Antarctic work has related to human impacts on the soil environment. This commenced under the farsighted initiative of Iain Campbell who led three expeditions with Graeme Claridge and Megan Balks in 1990–1992 with a focus on impacts of soil disturbance on the landscape and permafrost. These trips culminated in the development of the visual soil assessment method (VSA) for evaluating Antarctic soil surface disturbances (Campbell et al., 1993). The VSA method continues to be widely used across the Antarctic continent as a simple and

practical way of monitoring human impacts on the terrestrial environment. During this period some pioneering work was also undertaken to determine the ice content of permafrost and the effects of disturbance on permafrost ice content and potential for surface subsidence following disturbance (Campbell et al., 1994, 1998), along with work on metal contaminants in Antarctic soils (Claridge et al., 1995, 1999).

That research led on to a 20-year collaboration between Megan Balks and Dr Jackie Aislabie of Landcare Research (Fig. 13) which focussed firstly on impacts of oil spills on the Antarctic terrestrial environment (Aislabie et al., 1999, 2004, 2006, Balks et al., 2002, Holmes 2002), and then widened to a range of contaminants and physical disturbance activities and soil studies (e.g., Shanhun, 2005; Hofstee et al., 2006b). Tanya O'Neill undertook her PhD studying the effects of tourist activities on the Antarctic environment (O'Neill, 2013; O'Neill et al., 2012, 2013a, 2013b, 2014, 2015). Her research culminated in studies that focussed on soil recovery following disturbance (O'Neill et al., 2013b). The Antarctic environmental work also led to contributions to the Ross Sea region "State of the Environment" report (Campbell and Balks, 2001) and the Antarctic section of the FAO "Status of World Soils" report (Balks, 2015).

Fig. 13. Megan Balks and Jackie Aislabie at Cape Hallet, Ross Sea region, Antarctica, in the 2004-05 field season. Photo: M.R. Balks.

11. Teaching pedology, further contributions to the discipline, and awards

Since 2005, the soil science teaching at Waikato has been carried out mainly by David Lowe, Louis Schipper, and Megan Balks (Fig. 14). Each (along with Prof John McCraw) is a fellow of New Zealand Society of Soil Science (NZSSS) and each in addition has presented the annual N.H. Taylor Memorial Lecture of NZSSS (McCraw, 1979; Lowe, 2002b; Balks, 2009; Schipper, 2016). All three contributed recently to a global paper on teaching soil science by Hartemink et al. (2014). Their efforts were enhanced in 2014 by the appointment of Dr Tanya O'Neill as a teaching fellow (Fig. 14).

In 2011, David Lowe, with help from Louis Schipper and Megan Balks, developed a new graduate paper, "Land and Soil Evaluation". Part of the paper requires students to undertake farm-scale soil surveying and land-use capability (LUC) mapping on part of the Tokanui Research Farm to the south of Te Awamutu (using Manderson et al., 2007; Lynn et al., 2009) (Fig. 15). The exercise, developed with valued advice from Sharn Hainsworth, Gary Orbell, and Dr Richard Chapman (who left Waikato University in 2000 to form his consultancy "Soil and Land Evaluation"), is proving popular and worthwhile. Important contributions from Dr Debbie Care (Agritech) and Dr David Houlbrooke (AgResearch) complement the mapping and an exercise on N budgeting (Louis Schipper); work on soil quality, including reference to the "Soils 500" project (Louis Schipper, Tanya O'Neill, and Dr Brian Stevenson, Landcare Research) rounds out the paper.

Megan Balks completed a general introductory text book about the world of soils in 2016 (Balks and Zabowski, 2016). She 'retired' in February 2018 but continues as an Adjunct Senior Research Fellow in the School of Science at Waikato, remaining active in student supervision and undertaking writing work and other tasks that support soil science nationally and internationally.

Fig. 14. Staff of Department of Earth and Ocean Sciences at the University of Waikato on ~31 March 2014. The five chairs of the department who succeeded John McCraw (founding head of department, in front row, second from the end at far right) are present: Cam Nelson (8 years 1988-1995), Roger Briggs (6 years 1996-2001), Megan Balks (4 years 2002-2006), Dave Campbell (6 years 2006-2012), and David Lowe (2 years 2012-2014). The department was amalgamated into a new School of Science from 1 April 2014. Photo: N. Guest and M. Oulton.

Back row (left to right): Dean Sandwell, Karin Bryan, Shaun Barker, Peter Kamp, Aaron Wall, Janine Ryburn, Cam Nelson, Elizabeth Brodie, David Lowe, Earl Bardsley, Willem de Lange, Julia Mullarney, Hazel Needham, Chris Morcom, Roger Briggs, Renat Radosinsky, Dirk Immenga, Martin Danisik.
Front and middle rows (left to right): Tanya O'Neill, Louis Schipper, Xu Ganqing, James Neale, Annette Rodgers, Rochelle Hansen, Megan Balks, Adrian Pittari, Vicki Moon, Dave Campbell, Sydney Wright, Kirsty Vincent, John McCraw, Bethany Fox.

Another contribution by these staff to soil science has been to organise and host the biennial Waikato-Bay of Plenty regional soils conference in early December at Waikato University, the first being held in 2011 (Schipper and Lowe, 2012). These

one-day meetings cover a range of topics including pedology and attract around 60 participants (Fig. 17), with the fourth meeting held on 5 December, 2017, is designated World Soils Day annually).

Staff and students have also contributed to national and international conferences over the years (some noted above), including the national soils conference of NZSSS that was hosted on the University of Waikato campus in 2014. Balks and Schipper have served as elected representatives on the Council of NZSSS, and Lowe has served with the tephra commission of the International Union for Quaternary Research (INQUA). They have been editors or associate editors of soil-related scientific journals such as *Geoderma* and *Soil Science Society of America Journal,* and also Quaternary journals including *Quaternary International* and *Quaternary Geochronology.* All have written regularly for *New Zealand Soil News.*

Fig. 15. The next generation: graduate students of the "Land and Soil Evaluation" masterate class on 9 March, 2018, on Tokanui Farm near Te Awamutu. Photo: D.J. Lowe.

A point of great pride to the soil-science related academic staff at Waikato is the success of their graduates on the national stage, especially in winning NZSSS awards. Twenty graduates from the University of Waikato have won the Sir Theodore Rigg Award for best masterate thesis, 49% of the awards that have been made since the award was established in 1976. Another 14 have received the Dr Morice Fieldes Award for best doctoral thesis, 34% of the awards since 1976. Six Waikato graduates since 1993 have benefitted from being awarded the Bert Quin Bursary of NZSSS.

Louis Schipper was awarded the society's M.L. Leamy Award in 2014 for 'best publication in soil science for the past three years', primarily for his paper "Thermodynamic theory explains the temperature optima of soil microbial processes

and high Q10 values at low temperatures" (Schipper et al., 2014a). Louis was elected a Fellow of the Soil Science Society of America (2009). David Lowe, in contrast, won the McKay Hammer Award of the Geoscience Society of New Zealand in 2011 for the 'most meritorious papers in geology in New Zealand in the previous three years' for two tephra-based papers, Lowe et al. (2008b) and Lowe (2011). He was elected a Fellow of the Royal Society of New Zealand in 2010.

Fig. 16. 'Puke' or small mounds for growing kumara in the unique early Maori garden (called Te Parapara) at the Hamilton Gardens, on the lowest terrace underlain by Taupo Pumice Alluvium near the Waikato River, Hamilton, during the NZSSS conference held in December 2014. Participants in the background are being spoken to by the garden's designer, Wiremu Puke. Photo: D.J. Lowe.

12. Conclusions

Pedological and other soil-related teaching and research activities in the Department of Earth Sciences (and subsequent designations of the Earth sciences' group) at the University of Waikato for a 50-year period from 1969 to 2018 have been innovative and successful, and arguably have led to the development of special expertise in various disciplines, often collaboratively, within the Earth sciences. Key features of the 50-year history include:

(i) the new, integrative Earth sciences framework that was established by founding professor John McCraw and enacted initially by him and colleagues (professors Michael Selby and Harry Gibbs) and subsequent staff;

(ii) the development of teaching and research strengths in pedology, especially involving soil stratigraphy and tephra-derived soils in the central North Island and their unique mineralogical and physico-chemical properties, and the concomitant advancement of expertise in Quaternary tephrostratigraphy and tephrochronology;

(iii) the development of studies in rock and soil mechanics and engineering geology, and on slopes and slope stability, with specialist expertise regarding pyroclastic and associated deposits, especially weathered materials;

(iv) pathfinding research involving classical soil surveying and the subsequent growth of the use of GIS and geostatistical tools, aiding the later development of digital soil mapping beyond the university, and application to a wide range of disciplines including geomorphology, sustainable plantation forestry, and agriculture;

(v) pioneering and sustained research in Antarctica including soil surveying at a range of scales along with studies on human impacts;

(vi) a national peat survey, and many wide-ranging studies on peatlands, as well as environmental and carbon- and nitrogen-based research at multiple scales; and

(vii) the successful development of a strong postgraduate school involving pedology, soil science, and geomechanics disciplines. Notably, Waikato students have received around one half and one third of the NZSSS awards for 'best masterate thesis' and 'best doctoral thesis', respectively, since 1976.

Staff have contributed to the development of the "New Zealand Soil Classification", and staff and students in the department have convened or contributed to regional, national, and international conferences, including on behalf of NZSSS, and led many field trips, involving soils, pedology, tephras, or Earth sciences more generally. They have contributed in various other ways to the discipline of soil science. Four staff members have been awarded fellowships and the N.H. Taylor Memorial Lecture Award of NZSSS.

Fig. 17. Some of the participants in the biennial regional soils conference, 'Wai-BOP Soils 2013', hosted by the Department of Earth and Ocean Sciences, on World Soils Day (5 December), 2013. Photo: D.J. Lowe.

Acknowledgments

We thank Dr Phil Tonkin for inspiring this review. Phil's very substantial efforts in recording and publishing the history of soil science in its widest sense in New Zealand, and writing about its many practitioners, are priceless. All the staff and students who have been part of, and contributed to, the Earth sciences revolution at Waikato over the past 50 years are acknowledged and thanked. They have won respect and friends. Many graduates and postgraduates have gone on to fulfilling careers including leadership roles, contributing substantially to the advancement and dissemination of knowledge and to the development of New Zealand and other countries – a fitting legacy for founder Prof John McCraw and his staff and many others who have given much to provide the opportunities for Earth sciences to grow and flourish at the University of Waikato in Hamilton. Bonne chance to all those involved for the next 50 years!

References

Acorn, N. 2014. *Ko te Tangata: a History of the University of Waikato – the First Fifty Years.* University of Waikato, Hamilton, 334 p.

Adlam, L.S. 2009. Soil climate and permafrost temperature monitoring in the McMurdo Sound region, Antarctica. MSc thesis, University of Waikato, Hamilton.

Adlam, L.S., Balks, M.R., Seybold, C.A., Campbell, D.I. 2010. Temporal and spatial variation in active layer depth in the McMurdo Sound Region, Antarctica. *Antarctic Science* 22(1), 45-52.

Aislabie, J., Balks, M.R., Astori, N., Stevenson, G., Symons, R. 1999. Polycyclic aromatic hydrocarbons in fuel-oil contaminated soils, Antarctica. *Chemosphere* 39, 2201-2207.

Aislabie, J.M., Balks, M.R., Foght, J.M., Waterhouse, E.J. 2004. Hydrocarbon spills on Antarctic soils: effects and management. Critical review. *Environmental Science and Technology* 38(5), 1256-1274.

Aislabie, J.M., Chhour, K., Saul, D.J., Miyauchi, S., J. Ayton, J., Paetzold, R.F., Balks, M.R. 2006. Dominant bacteria in soils of Marble Point and Wright Valley, Victoria Land, Antarctica. *Soil Biology and Biochemistry* 38, 3041-3056.

Allbrook, R.F. 1980. The drop-cone penetrometer method for determining Atterberg limits. *New Zealand Journal of Science* 23, 93-97.

Allbrook, R.F. 1983. Some physical properties of allophane soils from the North Island, New Zealand. *New Zealand Journal of Science* 26, 481-492.

Allbrook, R.F. 1985. The effect of allophane on soil properties. *Applied Clay Science* 1, 65-69.

Allbrook, R.F. 1986. Effect of skid trail compaction on a volcanic soil in central Oregon. *Soil Science Society of America Journal* 50, 1344-1346.

Allbrook, R.F. 1989. The soil series. New Zealand Soil News 37, 88.

Allbrook, R.F. 1990. Bibliography of soil science in New Zealand up to 1957. Department of Earth Sciences, University of Waikato Occasional Report 14. 99 pp.

Allbrook, R.F. 1992. Shrinkage of some New Zealand soils and implications for soil physics. Australian Journal of Soil Research 31, 111-118.

Allbrook, R.F. 1997. Some aspects of the development of soil science in New Zealand. Advances in GeoEcology 29, 333-350.

Bakker, L. 1997.Towards a model of valley-side development on ignimbrite terrain, Mamaku Plateau, New Zealand. PhD thesis, University of Waikato, Hamiltton.

Bakker, L., Lowe, D.J., Jongmans, A.G. 1996a. A micromorphological study of pedogenic processes in an evolutionary soil sequence formed on Late Quaternary rhyolitic tephra deposits, North Island, New Zealand. *Quaternary International* 34-36, 249-261.

Bakker, L., Morad, M., Lowe, D.J. 1996b. Landform classification of the Mamaku Plateau using a digital elevation model. *Proceedings of Spatial Information Research Centre's 8th Colloquium,* University of Otago, 189-197.

Balks, M.R. 2009. Footprints at the end of the Earth: impacts and management of human activities on frozen soils. Norman Taylor Memorial lecture 2008. New Zealand Soil News 57 (1), 33-42.

Balks, M.R. 2015. Regional assessment of soil change in Antarctica. Chapter16 *in*: "Status of the World's Soil Resource". Food and Agriculture Organisation of the United Nations, pp. 520-526. Retrieved from http://www.fao.org/publications/en/

Balks, M.R., O'Neill, T.A. 2016. Soil and permafrost in the Ross Sea Region of Antarctica: stable or dynamic? Cuadernos De Investigacion Geografica 42, 415-434.

Balks, M.R., Zabowski, D. 2016. Celebrating Soil. Springer, Switzerland, 243 pp.

Balks, M.R., Paetzold, R.F., Kimble, J.M., Aislabie, J., Campbell, I.B. 2002. Effects of hydrocarbon spills on the temperature and moisture regimes of Cryosols in the Ross Sea region, Antarctica. *Antarctic Science* 14(4), 319-326.

Balks, M.R., McLeod, M., Bockheim, J.G. 2008. A provisional soil map of the Transantarctic Mountains, Antarctica. *In*: Kane, D.L., Hinkel, K.M. (editors), "NICOP 2008". 9th International Conference on Permafrost. Extended abstracts, pp. 13-14.

Balks, M.R., López-Martínez, J., Goryachkin, S.V., Mergelov, N.S., Schaefer, C.E.G.R., Simas, F.N.B., Almond, P.C., Claridge, G.G.C., Mcleod, M., Scarrow, J. 2013. Windows on Antarctic soil-landscape relationships: comparison across selected regions of Antarctica. *Geological Society (London) Special Publication* 381, 397-410.

Barrell, D.J.A., Almond, P.C., Vandergoes, M.J., Lowe, D.J., Newnham, R.M., NZ-INTIMATE members 2013. A composite pollen-based stratotype for inter-regional evaluation of climatic events in New Zealand over the past 30,000 years (NZ-INTIMATE project). *Quaternary Science Reviews* 74, 4-20

Bockheim, J.G., Balks, M.R. (editors) 2008. "Antarctic Soils and Soil Forming Processes in a Changing Environment". *Geoderma* 144 (1-2), 1-414.

Campbell, D.I., Williamson, J.L. 1997. Evaporation from a raised peat bog. *Journal of Hydrology* 193, 142–160.

Campbell, I.B., Balks, M.R. 2001. 4. Soils and ice-free areas. *In:* Waterhouse, E.J. (editor), "Ross Sea Region 2001: a State of the Environment Report for the Ross Sea Region of Antarctica". *New Zealand Antarctic Institute, Christchurch,* pp 4.16-4.35.

Campbell, I.B., Balks, M.R., Claridge, G.G.C. 1993. A simple visual technique for estimating the impact of fieldwork on the terrestrial environment in ice-free areas of Antarctica. *Polar Record* 29, 321-328.

Campbell, I.B., M.R. Balks, M.R., Claridge, G.G.C. 1994. The effect of human activities on moisture content of soils and underlying permafrost from the McMurdo Sound Region, Antarctica. *Antarctic Science* 6(3), 307-314.

Campbell, I.B., Claridge, G.G.C., Balks, M.R. 1998. Short- and long-term impacts of human disturbances on snow-free surfaces in Antarctica. *Polar Record* 34(188), 15-24.

Carshalton, A.G. in progress. The spatial and temporal variation in active-layer depth and permafrost in Scott Base and the Dry Valleys, Ross Sea region, Antarctica. MSc thesis project, University of Waikato, Hamilton.

Chabbi, A., Lehmann, J., Ciais, P., Loescher, H. W., Cotrufo, M. F., Don, A. Sanclements, M., Schipper, L., Six, J., Rumpel, C. 2017. Aligning agriculture and climate policy. *Nature Climate Change 7*(5), 307-309.

Chapman, R. 1983. Soil cobalt and agricultural implications in south Raglan County, New Zealand. MSc thesis, University of Waikato, Hamilton.

Chapman, R. 1992. The influence of subsoiling on soil physical properties and pasture production. PhD thesis, University of Waikato, Hamilton.

Chapman, R., Allbrook, R.F. 1987. The effects of subsoiling compacted soils under grass – a progress report. Proceedings Agronomy Society of New Zealand 17, 55-58.

Churchman, G.J., Lowe, D.J. 2012. Alteration, formation, and occurrence of minerals in soils. *In*: Huang, P.M., Li, Y., Sumner, M.E. (editors), "Handbook of Soil Sciences. 2nd edition. Vol. 1: Properties and Processes". CRC Press, Boca Raton, FL, pp.20.1-20.72.

Claridge, G.G.C., Campbell, I.J., Powell, H.K.J. Amin, Z.H., Balks, M.R. 1995. Heavy metal contamination in some soils of the McMurdo Sound region, Antarctica. *Antarctic Science* 7, 9-14.

Claridge, G.G.C., Campbell, I.B., Balks, M.R. 1999. Movement of salts in Antarctic soils: experiments using lithium chloride. *Permafrost and Periglacial Processes* 10, 223-233.

Clarke, R.S., Jr. 1982. The Derrick peak, Antarctica, iron meteorites. *Meteoritics* 17, 129-134.

Clarkson B.R., Thompson K., Schipper L.A., McLeod M. 1999. Moanatuatua bog – proposed restoration of a New Zealand restiad peat bog ecosystem. In: Streever, W. (editor), "An International Perspective on Wetland Rehabilitation". Springer, Dordrecht, pp. 127-137.

Clarkson, B.R., Schipper, L.A., Lehmann, A. 2004. Vegetation and peat characteristics in the development of lowland restiad peat bogs, North Island, New Zealand, since 13 000 ^{14}C years BP. *Wetlands* 24, 133–151.

Clarkson, B.R., Schipper, L.A., Silvester, W.B. 2009. Nutritional niche separation in co-existing bog species demonstrated by 15N-enriched simulated rainfall. *Austral Ecology* 34, 377-385.

Clayden, B., Hewitt, A.E. 1989. Horizon Notation for New Zealand Soils. DSIR Division of land and Soil Science Scientific Report 1. 30 pp.

Clayden, B., Hewitt, A.E., Parfitt, R.L. 1989. On defining soil series – a reply. *New Zealand Soil News* 37, 43-45.

Cotching, W.E., Allbrook, R.F., Gibbs, H.S. 1979. Influence of maize cropping on the soil structure of two soils in the Waikato district. *New Zealand Journal of Agricultural Research* 22, 431-438.
Cotton, C.A. 1942. Geomorphology – An Introduction to the Study of Landforms, 3rd edition. Whitcomb and Tombs, Christchurch, 503 pp.
Cunningham, M.J., Lowe, D.J., Wyatt, J.B., Moon, V.G., Churchman, G.J. 2016. Discovery of halloysite books in altered silicic Quaternary tephras, northern New Zealand. Clay Minerals 51, 351-372.
Dalrymple, J.B., Blong, R.J., Conacher, A.J. 1968. A hypothetical nine-unit landsurface model. Zeitschrift für Geomorphologie 12, 60-76.
Davoren, A.B. 1976. A pedological study of the Kauroa Ash Formation at the University of Waikato. MSc thesis, University of Waikato, Hamilton.
Davoren, A.B. [with McCraw, J.D., Thompson, K.] 1978. A survey of New Zealand peat resources. Ministry of Works, Water and Soil Technical Publication 14. Multiple maps + 157 pp.
de Lange, P.J., Lowe, D.J.1990. History of vertical displacement of Kerepehi Fault at Kopouatai bog, Hauraki Lowlands, New Zealand, since c. 10 700 years ago. New Zealand Journal of Geology and Geophysics 33, 277-283.
de Lange, P.J., Heenan, P.B., Clarkson, B.D., Clarkson, B.R. 1999. Sporadanthus in New Zealand. New Zealand Journal of Botany 37, 413-431.
Doyle, M.W., Julian, J.P. 2005. The most-cited works in Geomorphology. Geomorphology 72, 1-4.
Earth Sciences Staff 1987. Department of Earth Sciences 1970-1987. Department of Earth Sciences, University of Waikato, Occasional Report 12. 93 pp.
East, R., Willoughby, B.E. 1980. Effects of pasture defoliation in summer on grass grub (Costelytra zealandica) populations. New Zealand Journal of Agricultural Research 23, 547-562.
Fredericksen, D.C. 1988. A contribution to the geotechnical properties of allophanic soils from New Zealand. MSc thesis, University of Waikato, Hamilton.
Fry, J.D. 1976. A study of selected Holocene members of the Tongariro sub-group in the Kuratau-Waitahanui districts. MSc thesis, University of Waikato, Hamilton.
Gallen, R.G., Beca, G.S., McCraw, J.D., Roberts, T.A. 1980. Report of the Commission of Inquiry into the Abbotsford Landslip Disaster. Government Printer, Wellington, 195 pp.
Gehrels, M.J., Lowe, D.J., Hazell, Z.J., Newnham, R.M. 2006. A continuous 5300-yr Holocene cryptotephrostratigraphic record from northern New Zealand and implications for tephrochronology and volcanic-hazard assessment. *The Holocene* 16, 173-187.
Gehrels, M.J., Newnham, R.M., Lowe, D.J., Wynne, S., Hazell, Z.J., Caseldine, C. 2008. Towards rapid assay of cryptotephra in peat cores: review and evaluation of selected methods. *Quaternary International* 178, 68-84.
Gibbs, H.S. 1968. Volcanic-ash soils in New Zealand. *New Zealand DSIR Information Series* No. 65. 39 pp.
Gibbs, H.S. 1971a. The soil. *In*: "Turf Culture". *New Zealand Institute for Turf Culture*, 1-17 + 8 plates.
Gibbs, H.S. 1971b. Nature of paleosols in New Zealand and their classification. *In*: Yaalon, D.H. (editors), "Paleopedology: Origin, Nature, and Dating of Paleosols". International Society of Soil Science and Israel Universities Press, Jerusalem, 229-244.
Gibbs, H.S. 1974. Management of land and water resources. *In*: Johnston, R.J. (editor), "Society and Environment in New Zealand". Whitcombe and Tombs, Christchurch, pp. 170-184.
Gibbs, H.S. 1976. Soils of Tongatapu, Tonga. *New Zealand Soil Survey Report* 35.
Gibbs, H.S. 1980. *New Zealand Soils – An Introduction*. Oxford University Press, Wellington, 115 pp.
Gibbs, H.S. 1981. Soil and grassland: if grass needs soil, does soil need grass*? Proceedings of the New Zealand Grasslands Association* 42, 8-18.
Gibbs, H.S. 1982. Land use in New Zealand. *Department of Lands and Survey, Land Use Series Report* 16.
Gibbs, H.S. 1983. Development and plant relationships of lowland forest soils. *In*: Thompson, K., Hodder, A.P.W., Edmonds, A.S. (editors), "Lowland Forests in New Zealand". University of Waikato, Hamilton, pp. 35-44.
Gibbs, H.S., Lowe, D.J., Hogg, A.G. 1982. Parent materials of Yellow-brown loams in the Waikato-Coromandel district. *In:* Neall, V.E. (editor) "Soil Groups of New Zealand. Part 6. Yellow-brown loams". New Zealand Society of Soil Science, Lower Hutt, pp. 12-13.
Goddard, H.E. 2013. Investigation of air and soil climate across the latitudinal gradient of the Ross Sea region of Antarctica. MSc thesis, University of Waikato, Hamilton.
Goodrich, J.P., Campbell, D.I., Roulet, N.T., Clearwater, M.J., Schipper, L.A. 2015. Overriding control of methane flux temporal variability by water table dynamics in a Southern Hemisphere, raised bog. *Journal of Geophysical Research – Biogeosciences* 120, doi: 10.1002/2014JG002844.

Goodrich, J.P., Campbell, D.I., Schipper, L.A. 2017. Southern Hemisphere bog persists as a strong carbon sink during droughts. *Biogeosciences* 14, 4563-4576.
Grange, L.I. 1931. Volcanic ash showers. *New Zealand Journal of Science and Technology* 12, 228-240.
Grange, L.I., Taylor, N.H., Sutherland, C.F., Dixon, J.K., Hodgson, L., Seelye, F.T., Kidson, E., Cranwell, L.M., Smallfield, P. W. 1939. Soils and agriculture of part of Waipa County. *New Zealand Department of Scientific and Industrial Research Bulletin* 76.
Green, J.D., Lowe, D.J. 1985. Stratigraphy and development of c. 17 000 year old Lake Maratoto, North Island, New Zealand, with some inferences about postglacial climatic change. *New Zealand Journal of Geology and Geophysics* 28, 675-699.
Guglielmin, M., Balks, M.R., Adlam, L.S., Baio, F. 2011. Permafrost thermal regime from two 30-m deep boreholes in Southern Victoria Land, Antarctica. *Permafrost and Periglacial Processes*, *online*, 1-11, doi: 10.1002/ppp.715
Gumbley, W., Higham, T.F.G., Lowe, D.J. 2004. Prehistoric horticultural adaptation of soils in the middle Waikato Basin: review and evidence from S14/201 and S14/185, Hamilton. *New Zealand Journal of Archaeology* 25, 5-30.
Hainsworth, S.B. 2012. Properties and distribution of soils on the Ruataniwha Plains, Hawke's Bay: a new approach integrating classical and digital mapping techniques. MSc thesis, University of Waikato, Hamilton.
Harrowfield, D.L. 2007. Call of the Ice – Fifty Years of New Zealand in Antarctica. David Bateman, Auckland, 242 pp.
Hartemink, A.E., Balks, M.R., Chen, Z-S., Drohan, P., Field, D.J., Krasilnikov, P., Lowe, D.J., Rabenhorst, M., van Rees, K., Schad, P., Schipper, L.A., Sonneveld, M., Walter, C. 2014. The joy of teaching soil science. *Geoderma* 217-218, 1-9.
Heaphy, M.J., Lowe, D.J., Palmer, D.J., Jones, H.S., Gielen, G.J.H.P., Oliver, G.R., Pearce, S.H., 2014. Assessing drivers of plantation forest productivity on eroded and non-eroded soils in hilly land, eastern North Island, New Zealand. *New Zealand Journal of Forestry Science* 44: 24 (10 pp.).
Hewitt, A.E. 1978. New Zealand Soil Classification (Version 1.0). *DSIR Soil Resources Report* SR15. 69 pp.
Hewitt, A.E. 1992a. Soil classification in New Zealand – legacy and lesson. *Australian Journal of Soil Research* 30, 843-854.
Hewitt, A.E. 1992b. New Zealand Soil Classification. *DSIR Land Resources Scientific Report* 19. 133 pp.
Hewitt, A.E. 1993. Methods and rationale of the New Zealand Soil Classification. *Landcare Research Science Series* 2. Manaaki Whenua Press. 71 pp.
Hewitt, A.E. 2010. New Zealand Soil Classification 3rd edition. *Landcare Research Science Series* 1. 136 pp.
Hodder, A.P.W. 1974. The use of physical and chemical techniques in the identification of tephra (volcanic ash) in the North Island, New Zealand. DPhil thesis, University of Waikato, Hamilton.
Hodder, A.P.W., Wilson, A.T., 1976. Identification and correlation of thinly bedded tephra: the Tirau and Mairoa ashes. *New Zealand Journal of Geology and Geophysics* 19, 663-682.
Hodder, A.P.W., Green, B.E., Lowe, D.J. 1990. A two-stage model for the formation of clay minerals from tephra-derived volcanic glass. *Clay Minerals* 25, 313-327.
Hodder, A.P.W., de Lange, P.J., Lowe, D.J. 1991. Dissolution and depletion of ferromagnesian minerals from Holocene tephras in an acid bog, New Zealand, and implications for tephra correlation. *Journal of Quaternary Science* 6, 195-208.
Hofstee, E.H. 2006. Soils and hydrology of Seabee Hook, Cape Hallett, Antarctica. MSc thesis. University of Waikato, Hamilton.
Hofstee, E.H., Balks, M.R., Petchey, F., Campbell, D.I. 2006a. Soils of Seabee Hook, Cape Hallett, northern Victoria Land, Antarctica. *Antarctic Science* 18(4), 473-486.
Hofstee, E.H.,Campbell, D.I., Balks, M.R., Aislabie, J. 2006b. Groundwater characteristics at Seabee Hook, Cape Hallett, Antarctica. *Antarctic Science* 18(4), 487-495.
Hogg, A.G. 1974. A pedological study of the Hamilton Ash Formation at Te Uku. MSc thesis, University of Waikato, Hamilton.
Hogg, A.G. 1979. Identification and correlation of thinly bedded late QuaternGIY tephras of Coromandel Peninsula, New Zealand. PhD thesis, University of Waikato, Hamilton.
Hogg, A.G., McCraw, J.D., 1983. Late Quaternary tephras of Coromandel Peninsula, North Island, New Zealand: a mixed peralkaline and calcalkaline tephra sequence. *New Zealand Journal of Geology and Geophysics* 26, 163-187.

Hogg, A.G., Lowe, D.J., Hendy, C.H. 1987. University of Waikato radiocarbon dates I. *Radiocarbon* 29, 263-301.

Hogg, A.G., Higham, T.F.G., Lowe, D.J., Palmer, J., Reimer, P., Newnham, R.M. 2003. A wiggle-match date for Polynesian settlement of New Zealand. *Antiquity* 77, 116-125.

Hogg, A.G., Lowe, D.J., Palmer, J.G., Boswijk, G., Bronk Ramsey, C.J. 2012. Revised calendar date for the Taupo eruption derived by ^{14}C wiggle-matching using a New Zealand kauri ^{14}C calibration data set. *The Holocene* 22, 439-449.

Holmes, D.J. 2002. Fate and effects of JP-5 fuel in Antarctic soil: a controlled experiment at Scott Base, Antarctica. MSc thesis, University of Waikato, Hamilton.

Horrocks, J.L. 2000. Stratigraphy, chronology and correlation of the Plio-Pleistocene (*c.* 2.2-0.8 Ma) Kauroa Ash sequence, western central North Island, New Zealand. PhD thesis, University of Waikato, Hamilton.

Huang, Y-T., Lowe, D.J., Zhang, H., Cursons, R., Young, J.M., Churchman, G.J., Schipper, L.A., Rawlence, N.J., Wood, J.R., Cooper, A. 2016a. A new method to extract and purify DNA from allophanic soils and paleosols, and potential for paleoenvironmental reconstruction and other applications. *Geoderma* 247, 114-125.

Huang, Y-T., Lowe, D.J., Churchman, G.J., Schipper, L.A., Cursons, R., Zhang, H., Chen, T.-Y., Cooper, A. 2016b. DNA adsorption by nanocrystalline allophane spherules and nanoaggregates, and implications for carbon sequestration in Andisols. *Applied Clay Science* 120, 40-50.

Jones, H.S. 1998. Evaluating soil classification and soil-landscape modelling for site-specific forest management, Woodlaw Forest, Southland, New Zealand. MSc thesis, University of Waikato, Hamilton.

Jones, H.S. 2004. Impacts of forest harvesting on performance of soil-landscape modelling in a radiata pine forest, northern New Zealand. PhD thesis, University of Waikato, Hamilton.

Jones, H.S., Lowe, D.J., McLay, C.D.A. 1997. Soil-landscape modelling and soil property variability for forestry land evaluation in Longwood Forest, Southland. Phase 1: Soil-landscape model development. *Progress Report No.1 for Rayonier New Zealand Ltd*. University of Waikato, Hamilton. 54 pp.

Jones, H.S., Lowe, D.J., Rijkse, W.C., McLay, Payn, T.W. 2000. A soil-landscape model for southern Mahurangi Forest, Northland. *Mahurangi Forest-Soil Project Report No. 1 to Forest Research*. Department of Earth Sciences, University of Waikato. 63 pp.

Kamp, P.J.J., Lowe, D.J. 1982. Geology and terrestrial age of the Derrick Peak meteorite occurrence, Antarctica. *Meteoritics* 17, 119-127.

Kleyburg, M.A., Moon, V.G., Lowe, D.J., Nelson, C.S. 2015. Paleoliquefaction in Late Pleistocene alluvial sediments in Hauraki and Hamilton basins, and implications for paleoseismicity. Proceedings of the 12th Australia New Zealand Conference on Geomechanics (ANZ 2015), 22-25 February, 2015, Wellington, pp. 524-531.

Kluger, M.O., Moon, V.G., Kreiter, S., Lowe, D.J., Churchman, G.J., Hepp, D.A., Seibel, D., Jorat, M.E., Mörz, T. 2017. A new attraction-detachment model for explaining flow sliding in clay-rich tephras. *Geology* 45, 131-134.

Lane, C.S., Lowe, D.J., Blockley, S.P.E., Suzuki, T., Smith, V.C. 2017. Advancing tephrochronology as a global dating tool: applications in volcanology, archaeology, and palaeoclimatic research. *Quaternary Geochronology* 40, 1-7.

Lanigan, K. 2012. Stratigraphy and character of tephric-loess deposits aged from c. 33 to 9.5 cal ka in the Rotorua area, northern New Zealand, and some inferences about past climates. MSc thesis, University of Waikato, Hamilton.

Laubscher, N. 2014. Improvement in soil water availability in pastures by excavating and mixing buried soil horizons from multilayered Pumice Soils (Vitrands) at Galatea, central North Island, New Zealand. MSc thesis, University of Waikato, Hamilton.

Linehan, J.P. 2015. Distribution of soils in the southern Hawke's Bay greywacke foothills land system. BSc (Hons) dissertation, University of Waikato, Hamilton.

Lowe, D.J. 1979. Soils of Steele's Farm, Airport Rd, Rukuhia, with 1:1250 map. Ruakura Agricultural Research Centre [per B. Willoughby], Ministry of Agriculture and Fisheries (MAF), Hamilton.

Lowe, D.J. 1981. Origin, composite nature, and pedology of late Quaternary airfall deposits, Hamilton Basin, New Zealand. MSc thesis, University of Waikato, Hamilton .

Lowe, D.J. 1985. Application of impulse radar to continuous profiling of tephra-bearing lake sediments and peats: an initial evaluation. *New Zealand Journal of Geology and Geophysics* 28, 667-674.

Lowe, D.J. 1986. Controls on the rates of weathering and clay mineral genesis in airfall tephras: a review and New Zealand case study. *In:* Colman, S.M., Dethier, D.P. (editors), "Rates of Chemical Weathering of Rocks and Minerals". Orlando, Academic Press, pp. 265-330.

Lowe, D.J. 1988a. Stratigraphy, age, composition, and correlation of late Quaternary tephras interbedded with organic sediments in Waikato lakes, North Island, New Zealand. *New Zealand Journal of Geology and Geophysics* 31, 125-165.
Lowe, D.J. 1988b. Late Quaternary volcanism in New Zealand: towards an integrated record using distal airfall tephras in lakes and bogs. *Journal of Quaternary Science* 3, 111-120.
Lowe, D.J. 1989. Distinguishing rhyolitic and andesitic tephra as soil parent materials for series definition. *New Zealand Soil News* 37, 90-93.
Lowe, D.J. 1990a. Tephra studies in New Zealand: an historical review. *Journal of the Royal Society of New Zealand* 20, 119-150.
Lowe, D.J. 1990b. Review of "Horizon Notation for New Zealand Soils" by B. Clayden and A.E. Hewitt. *New Zealand Soil News* 38, 33-34.
Lowe, D.J. 1992. Review of "New Zealand Soil Classification" by A.E. Hewitt. *New Zealand Soil News* 40, 201-206.
Lowe, D.J. (editor) 1994. Conference Tour Guides. *International Inter-INQUA Field Conference on Tephrochronology, Loess, and Paleopedology*, University of Waikato, Hamilton, New Zealand, 186 pp.
Lowe, D.J. 1995. Teaching clays: from ashes to allophane. *In*: Churchman, G.J., Fitzpatrick, R.W., Eggleton, R.A. (editors), *Clays: Controlling the Environment.* Proceedings 10th International Clay Conference, Adelaide, Australia (1993). CSIRO Publishing, Melbourne, pp. 19-23.
Lowe, D.J. (editor) 1996. "Tephra, Loess, and Paleosols – An Integration". *Quaternary International* 34-36, 261 pp.
Lowe, D.J. 2002a. Soil science at the University of Waikato: a brief history. *In*: Adams, J.A. (editor), "Jubilee Reminiscences: Fifty Years of Soil Science Memories". *New Zealand Society of Soil Science Occasional Publication* 3, 37-39.
Lowe, D.J. 2002b. The time machine. Norman Taylor Memorial Lecture 2002. *New Zealand Soil News* 50, 124-135.
Lowe, D.J. (compiler) 2006. Guidebook for 'Land and Lakes' field trip, New Zealand Society of Soil Science Biennial Conference, Rotorua. New Zealand Society of Soil Science. 63 pp.
Lowe, D.J. (compiler) 2008. Guidebook for Pre-conference North Island Field Trip A1 'Ashes to Issues', 28-30 November, 2008. Australian and New Zealand 4th Joint Soils Conference, Massey University, Palmerston North (1-5 December). *New Zealand Society of Soil Science*. 194 pp.
Lowe, D.J. 2010. Quaternary volcanism, tephras, and tephra-derived soils in New Zealand: an introductory review. *In*: Lowe, D.J., Neall, V.E., Hedley, M., Clothier, B., Mackay, A. (compilers), Guidebook for Pre-conference North Island, New Zealand 'Volcanoes to Oceans' Field Tour (27-30 July). 19th World Soils Congress, International Union of Soil Sciences, Brisbane. *Soil and Earth Sciences Occasional Publication No. 3*, Massey University, Palmerston North, pp. 7-29.
Lowe, D.J. 2011. Tephrochronology and its application: a review. *Quaternary Geochronology* 6, 107-153.
Lowe, D.J. 2016. Introduction to tephra-derived soils, North Island, New Zealand: University of Waikato and University of Wisconsin-Platteville post-conference Andisol Excursion, 21-23 December, 2016. Guidebook for 3-day field trip following the joint conference of New Zealand Society of Soil Science and Soil Science Australia, Queenstown, New Zealand, 12-16 December. School of Science, University of Waikato, Hamilton. 74 pp.
Lowe, D.J., Balks, M.R. 1996. Review of "Soil Description Handbook – Revised Edition" by J.D.G. Milne et al. *New Zealand Soil News* 44, 117-119.
Lowe, D.J., Churchman, G.J. 2016. Tales of the unexpected: halloysite delivers surprises and a paradox. *New Zealand Soil News* 64 (4), 12-18.
Lowe, D.J., Green, B.E. 1992. A hydrofluoric acid dissolution method for determining volcanic glass content of tephra-derived soils (Andisols). *Australian Journal of Soil Research* 30, 573-581.
Lowe, D.J., Hogg, A.G. 1986. Tephrostratigraphy and chronology of the Kaipo Lagoon, an 11,500 year-old montane peat bog in Urewera National Park, New Zealand. *Journal of the Royal Society of New Zealand* 16, 25-41.
Lowe, D.J., Nelson, C.S. 1983. Guide to the nature and methods of analysis of the clay fraction of tephras in the South Auckland region, New Zealand. *Department of Earth Sciences, University of Waikato Occasional Report* 11. 69 pp. [Second printing in 1994 with revised preface, new references, and corrections]
Lowe, D.J., Palmer, D.J. 2005. Andisols of New Zealand and Australia. *Journal of Integrated Field Science* 2, 39-65.
Lowe, D.J., Percival, H.J. 1993. Clay mineralogy of tephras and associated paleosols and soils, and hydrothermal deposits, North Island [New Zealand]. *Review and Guide F1 Field Tour – New Zealand*. Tenth International Clay Conference, Adelaide, Australia, 110 pp.

Lowe, D.J., Tonkin, P.J. 2010. Unravelling upbuilding pedogenesis in tephra and loess sequences in New Zealand using tephrochronology. *In*: Gilkes, R.J., Prakongkep, N. (editors), Proceedings of the 19th World Congress of Soil Science "Soil Solutions for a Changing World" (1-6 August, Brisbane), Symposium 1.3.2 Geochronological techniques and soil formation, pp. 34-37. Published at http://www.iuss.org.

Lowe, D.J., Hogg, A.G., Hendy, C.H. 1981. Detection of thin tephra deposits in peat and organic lake sediments by rapid X-radiography and X-ray fluorescence techniques. *Geology Department, Victoria University of Wellington Publication* 20, 74-77.

Lowe, D.J., Wigley, G.N.A., Dahm, J., Nagatomo, Y. 1992. Late Quaternary tephrostratigraphy and Holocene dune development in the Papamoa-Te Puke area, Bay of Plenty. *In:* Rijkse, W.C. (editor), 'Notes for Field Days 1992 Conference'*. New Zealand Society of Soil Science*, 36-41.

Lowe, D.J., McFadgen, B.G., Higham, T.F.G., Hogg, A.G., Froggatt, P.C., Nairn, I.A. 1998. Radiocarbon age of the Kaharoa Tephra, a key marker for late-Holocene stratigraphy and archaeology in New Zealand. *The Holocene* 8, 487-495.

Lowe, D.J., Newnham, R.M., Ward, C.M. 1999. Stratigraphy and chronology of a 15 ka sequence of multi-sourced silicic tephras in a montane peat bog, eastern North Island, New Zealand. *New Zealand Journal of Geology and Geophysics* 42, 565-579.

Lowe, D.J., Newnham, R.M., McFadgen, B.G., Higham, T.F.G. 2000. Tephras and New Zealand archaeology. *Journal of Archaeological Science* 27, 859-870.

Lowe, D.J., Tippett, J.M., Kamp, P.J.J., Liddell, I.J., Briggs, R.M., Horrocks, J.L. 2001. Ages on weathered Plio-Pleistocene tephra sequences, western North Island, New Zealand. *Les Dossiers de l'Archeo-Logis* 1, 45-60.

Lowe, D.J., Newnham, R.M., McCraw, J.D. 2002. Volcanism and early Maori society in New Zealand. *In*: Torrence, R., Grattan, J. (editors), "Natural Disasters and Cultural Change". Routledge, London, pp. 126-161.

Lowe, D.J., Tonkin, P.J., Neall, V.E., Palmer, A.S., Alloway, B.V., Froggatt, P.C. 2008a. Colin George Vucetich (1918–2007) – pioneering New Zealand tephrochronologist. *Quaternary International* 178, 11-15.

Lowe, D.J., Shane, P.A.R., Alloway, B.V., Newnham, R.M. 2008b. Fingerprints and age models for widespread New Zealand tephra marker beds erupted since 30,000 years ago: a framework for NZ-INTIMATE. *Quaternary Science Reviews* 27, 95-126.

Lowe, D.J., Neall, V.E., Hedley, M., Clothier, B., Mackay, A. 2010. Guidebook for pre-conference North Island, New Zealand 'Volcanoes to Ocean' field tour (27-30 July). 19th World Soils Congress, International Union of Soil Sciences, Brisbane. *Soil and Earth Sciences Occasional Publication* No. 3, Massey University, Palmerston North. 239 pp.

Lowe, D.J., Moriwaki, H., Davies, S.M., Suzuki, T., Pearce, N.J.G. (editors) 2011. "Enhancing Tephrochronology and its Application (INTREPID project): Hiroshi Machida Commemorative Volume." *Quaternary International* 246, 1- 395.

Lowe, D.J., Lanigan, K.M., Palmer, D.J. 2012. Where geology meets pedology: Late Quaternary tephras, loess, and paleosols in the Mamaku Plateau and Lake Rerewhakaaitu areas. *In*: Pittari, A. (compiler), Field Trip Guides, Geosciences 2012 Conference, Hamilton, New Zealand. *Geoscience Society of New Zealand Miscellaneous Publication* 134B, pp. 2.1–2.45.

Lowe, D.J., Blaauw, M., Hogg, A.G., Newnham, R.M. 2013. Ages of 24 widespread tephras erupted since 30,000 years ago in New Zealand, with re-evaluation of the timing and palaeoclimatic implications of the late-glacial cool episode recorded at Kaipo bog. *Quaternary Science Reviews* 74, 170-194.

Lowe, D.J., Balks, M.R., Laubscher, N. 2014. Once despised now desired: innovative land use and management of multilayered Pumice Soils in the Taupo and Galatea areas, central North Island, New Zealand. Guidebook for field trip 'Hot volcanic soils', New Zealand Society of Soil Science conference "Soil Science for Future Generations", Hamilton (1-4 December), 85 pp.

Lowe, D.J., Tonkin, P.J., Palmer, J., Lanigan, K., Palmer, A.S. 2015. Dusty horizons *In*: Graham, I.J. (editor), "A Continent on the Move: New Zealand Geoscience Revealed, 2nd Edition". GNS Science and Geoscience Society of New Zealand*. GSNZ Miscellaneous Publication* 141*,* pp. 286-289.

Lowe, D.J., Pearce, N.J.G., Jorgensen, M.A., Kuehn, S.C., Tryon, C.A., Hayward, C.L. 2017a. Correlating tephras and cryptotephras using glass compositional analyses and numerical and statistical methods: review and evaluation. *Quaternary Science Reviews* 175, 1-44.

Lowe, D.J., Tonkin, P.J., Leslie, D.M., Cotching, W.E. 2017b. Obituary – Willem 'Wim' Cornelis Rijkse (1936-2017). *New Zealand Soil News* 65 (4), 10-20.

Lynn, I., Manderson, A., Page, M., Harmsworth, G., Eyles, G., Douglas, G., Mackay, A., Newsone, P. 2009. *Land Use Capability Survey Handbook 3rd edition*. AgResearch, Hamilton; Landcare Research, Lincoln; GNS Science, Lower Hutt. 162 pp.

Macky, J.S. 1997. Stratigraphy, chronology, and correlation of post-230,000 yr BP cover beds, Tapapa-Tauranga region, North Island, New Zealand. MSc thesis, University of Waikato, Hamilton

Manderson, A., Palmer, A., Mackay, A., Wilde, H., Rijkse, W. 2007. *Introductory Guide to Farm Soil Mapping*. AgResearch, Palmerston North. Sheets + 64 pp.

McCraw, J.D. 1956. Soil survey of the Upper Shotover Catchment. Pp. 16-23 in Shotover River Survey (Upper catchment). *Otago Catchment Board Bulletin* 1. 72 pp.

McCraw, J.D. 1959. Periglacial and allied phenomena in western Otago. *New Zealand Geographer* 15, 61-68.

McCraw, J.D. 1962. Sequences in the mountain soil pattern of Central and western Otago. *Proceedings of the New Zealand Society of Soil Science* 5, 16-18.

McCraw, J.D. 1964. Soils of the Alexandra District. *New Zealand Soil Bureau Bulletin* 24. 92 pp.

McCraw, J.D. 1967a. Soils of the Taylor Dry Valley, Victoria Land, Antarctica, with notes on soils from other localities in Victoria Land. *New Zealand Journal of Geology and Geophysics* 10, 498-539.

McCraw, J.D. 1967b. Some surface features of McMurdo Sound region, Victoria Land, Antarctica. *New Zealand Journal of Geology and Geophysics* 10, 394-417.

McCraw, J.D. 1967c. The surface features and soil pattern of the Hamilton Basin. *Earth Science Journal* 1, 59-74.

McCraw, J.D. 1968. The soil pattern of some New Zealand alluvial fans. *Transactions of the 9th International Congress of Soil Science* 4, 631-640.

McCraw, J.D. 1974. Soils of the northern King Country. *Proceedings of the New Zealand Grasslands Association* 35, 15-21.

McCraw, J.D. 1975. Airfall deposits of New Zealand. *Royal Society of New Zealand Bulletin* 13, 35-44.

McCraw, J.D. 1979. No man's land. Norman Taylor Memorial Lecture for 1978. *New Zealand Soil News* 27, 6-16.

McCraw, J.D. 2002a. The physical environment. *In*: Clarkson, B.D., Merrett, M., Downs, T. (compilers), "Botany of the Waikato". Waikato Botanical Society, Hamilton, pp. 13-20.

McCraw, J.D. 2002b. Geology or Earth sciences? *In*: Adams, J.A. (editor), "Jubilee Reminiscences: Fifty years of soil science memories". *New Zealand Society of Soil Science Occasional Publication* 3, 40-42.

McCraw, J.D. 2011. *The Wandering River: Landforms and Geological History of the Hamilton Basin*. Geoscience Society of New Zealand, Guide Book No. 16. 85 pp.

McCraw, J.D., Bell, J.L. 1975. Soils. *In*: "Land Inventory Survey, Coromandel–Thames Counties". Department of Lands and Survey, Wellington, pp. 30-49.

McCraw, J.D., Whitton, J.S. 1971. Soils of Mayor Island, Bay of Plenty, New Zealand. *New Zealand Journal of Science* 14, 1009-1025.

McDaniel, P.A., Lowe, D.J., Arnalds, O., Ping, C.-L. 2012. Andisols. *In*: Huang, P.M., Li, Y., Sumner, M.E. (editors), "Handbook of Soil Sciences. 2nd edition. Vol. 1: Properties and Processes". CRC Press, Boca Raton, FL, pp.33.29-33.48.

McDonald, W.S. 1985. A comparison of soil structure under *Pinus radiata* and pasture. MSc thesis, University of Waikato, Hamilton.

McKay, A.M., Lowe, D.J., Moon, V.G. 2017. Evaluating soil and landscape models to predict liquefaction susceptibility in the Hinuera Formation, Hamilton Basin. *In*: Alexander, G.J., Chin, C.Y. (editors), "Proceedings of the 20th New Zealand Geotechnical Society Symposium", 24-26 November 2017, Napier, 8 pp.

McLay, C.D.A., Allbrook, R.F., Thompson, K. 1992. Effect of development and cultivation on physical properties of peat soils in New Zealand. *Geoderma* 54, 23-37.

McLauchlan, K. 2001. The suitability of land adjacent to the Te Awamutu oxidation ponds for the removal of phosphorus. BSc(Hons) dissertation, University of Waikato, Hamilton.

McLeod, M. 2012. Soil and permafrost distribution, soil characterisation and soil vulnerability to human foot trampling, Wright Vallley, Antarctica. PhD thesis, University of Waikato, Hamilton.

McLeod, M., Bockheim, J.G., Balks, M.R. 2008. Glacial geomorphology, soil development and permafrost features in central-upper Wright Valley, Antarctica. Geoderma 144(1-2), 93-103.

McLeod, M., Bockheim, J., Balks, M., Aislabie, J. 2009. Soils of western Wright Valley, Antarctica. Antarctic Science 214, 355-365.

Milne, D., Clayden, B., Singleton, P., Wilson, A. 1995. Soil Description Handbook, revised edition. Manaaki Whenua Press. 157 pp.

Moon, V.G. 2016. Halloysite behaving badly: geomechanics and slope behaviour of halloysite-rich soils. Clay Minerals 51, 517-528.

Moon, V.G., de lange, W.P. 2017. Potential shallow seismic sources in the Hamilton Basin: final report for EQC project No.16/717 (5 July 2017). School of Science, University of Waikato, Hamilton, 41 pp.

Moon, V.G., Lowe, D.J., Cunningham, M.J., Wyatt, J., Churchman, G.J., de Lange, W.P., Mörz, T., Kreiter, S., Kluger, M.O., Jorat, M.E. 2015a. Sensitive pyroclastic-derived halloysitic soils in northern New Zealand: interplay of microstructure, minerals, and geomechanics. *In*: Rotonda, T., Cecconi, M., Silvestri, F., Tommasi, P. (editors), "Volcanic Rocks and Soils". Proceedings of the International Workshop on Volcanic Rocks and Soils, Lacco Ameno, Ischia Island, Italy, 24-25 September, 2015. Taylor and Francis, London, pp. 3-21.

Moon, V.G., de Lange, W.P., Garae, C.P., Mörz, T., Jorat, M.E., Kreiter, S. 2015b. Monitoring the landslide at Bramley Drive, Tauranga, NZ. Proceedings, 12th Australia New Zealand Conference on Geomechanics: ANZ 2015, "Changing the Face of the Earth – Geomechanics and Human Influence", Wellington, 8 pp.

Moon, V.G., Mills, P.R., Kluger, M.O., Lowe, D.J., Churchman, G.J., de Lange, W.P., Hepp, D.A., Kreiter, S., Mörz, T., 2017. Sensitive pyroclastic soils in the Bay of Plenty, New Zealand: microstructure to failure mechanisms. In: Alexander, G.J., Chin, C.Y. (editors), "Proceedings 20th New Zealand Geotechnical Society Symposium", 24-26 November 2017, Napier, 8 pp.

Nelson, C.S. 2000. Publication record for the Department of Earth Sciences, University of Waikato, New Zealand – the first three decades (1970-1999). Department of Earth Sciences, University of Waikato, Occasional Report 24. 133 pp.

Nelson, C.S. (with colleague contributions) 2018. The working life of Michael John Selby (1936-2018): a highly influential late 20th century New Zealand geomorphologist and university leader. Geoscience Society of New Zealand Miscellaneous Publication (in press).

Nelson, C.S., Lowe, D.J., Tonkin, P.J. 2015. The working life of John McCraw (1925-2014): a remarkable New Zealand pedologist and Earth scientist. *Journal of the Historical Studies Group (Geoscience Society of New Zealand)* 50, 2-29.

Newnham, R.M., Lowe, D.J. 2000. Fine-resolution pollen record of late-glacial climate reversal from New Zealand. *Geology* 28, 759-762

Newnham, R.M., Lowe, D.J., Green, J.D. 1989. Palynology, vegetation, and climate of the Waikato lowlands, North Island, New Zealand, since c. 18 000 years ago. *Journal of the Royal Society of New Zealand* 19, 127-150.

Newnham, R.M., de Lange, P.J., Lowe, D.J. 1995. Holocene vegetation, climate, and history of a raised bog complex, northern New Zealand, based on palynology, plant macrofossils and tephrochronology. *The Holocene* 5, 267-282.

Newnham, R.M., Lowe, D.J., McGlone, M.S., Wilmshurst, J.M., Higham, T.F.G. 1998. The Kaharoa Tephra as a critical datum for earliest human impact in northern New Zealand. *Journal of Archaeological Science* 25, 533-544.

Newnham, R.M., Lowe, D.J., Williams, P.W. 1999. Quaternary environmental change in New Zealand: a review. *Progress in Physical Geography* 23, 567-610.

Newnham, R.M., Lowe, D.J., Gehrels, M.J., Augustinus, P. 2018. Two-step human–environmental impact history for northern New Zealand linked to late-Holocene climate change. *The Holocene* (online 22 March 2018, pp. 1-14), https://doi.org/10.1177/09596836187615

Nieveen, J., Schipper, L. 2005. The carbon budget of New Zealand peatlands. *In*: Whinam, J. and Hope, G.S. (editors), "The peatlands of the Australasian region". *In*: Steiner, G.M. (editor), "Mires from Siberia to Tierra del Fuego". Biologiezentrum der Oberoesterreichischen Landesmussen (Museum of Upper Austria), Linz, p. 411.

Northey, R.D., Gibbs, H.S. 1976. Soil map of Pauatahanui area, Wellington, New Zealand. Scale 1:25,000. *New Zealand Soil Bureau Map* 157 (accompanies New Zealand Soil Bureau Report 13).

Noyes, A.M., Balks, M.R., Moon, V.G., Lowe, D.J. 2016. Soil recovery following landsliding at Whatawhata Research Station, Waikato, New Zealand: preliminary results. *Proceedings of Hill Country Symposium 2016* (New Zealand Grassland Association, New Zealand Society of Animal Production, and New Zealand Grassland Trust, 12-13 April 2016, Rotorua), pp. 83-88.

O'Neill, T.A. 2013. Soil physical impacts and recovery rates following human-induced disturbances in the Ross Sea region of Antarctica. PhD thesis, University of Waikato, Hamilton.

O'Neill, T.A., Balks, M.R., Lopez-Martinez, J., McWhirter, J.L. 2012. A method for assessing the physical recovery of Antarctic desert pavements following human-induced disturbances: a case study in the Ross Sea region of Antarctica. Journal of Environmental Management 112, 415-428.

O'Neill, T.A., Balks, M.R., López-Martinez, J. 2013a. The effectiveness of environmental impact assessments on visitor activity in the Ross Sea region of Antarctica. In: Müller, D.K., Lundmark,

L., Lemelin, R.H. (editors), "New Issues in Polar Tourism: Communities, Environments, Politics". Springer, The Netherlands, pp. 87-110.
O'Neill, T.A., Balks, M.R., Lopez-Martinez, J. 2013b. Visual recovery of desert pavement surfaces following impacts from vehicle and foot traffic in the Ross Sea region of Antarctica. Antarctic Science 25(4), 514-530.
O'Neill, T. A., Balks, M. R., & López-Martínez, J. 2014. Ross Island recreational walking tracks: relationships between soil physiochemical properties and track usage. Polar Record 51 (4), 444-455.
O'Neill, T.A., Aislabie, J., Balks, M.R. 2015. Human impacts on soils. In: Bockheim, J.G. (editor), "The Soils of Antarctica". World Soils Book Series, Springer, Dordrecht, pp. 281-303.
Palmer, R.W.P. 1974. Soil variation on hillslopes at Whatawhata. MSc thesis, University of Waikato, Hamilton.
Palmer, D.J. 2002. Testing a soil-phosphate-driven model of forest sustainability developed for Kinleith Forest, southern Mamaku Plateau, New Zealand. MSc thesis, University of Waikato, Hamilton.
Palmer, D.J. 2008. Development of national extent terrain attributes (TANZ), soil water balance surfaces (SWatBal), and environmental surfaces, and their application for spatial modelling of Pinus radiata productivity across New Zealand. PhD thesis, University of Waikato, Hamilton.
Palmer, R.W.P., Neall, V.E., Pollok, J.A. 1981. Soils of Egmont and part Taranaki counties, North Island, New Zealand. New Zealand Soil Survey Report 64. Map 1: 50,000 + 68 pp.
Palmer, D.J., Lowe, D.J., Payn, T.W., Höck, B.K., McLay, C.D.A., Kimberley, M.O. 2005. Soil and foliar phosphorus as indicators of sustainability for Pinus radiata plantation forestry in New Zealand. Forest Ecology and Management 220, 140-154.
Palmer, D.J., Höck, B.K., Kimberley, M.O., Lowe, D.J., Payn, T.W. 2009a. Comparison of spatial prediction techniques for developing Pinus radiata productivity surfaces across New Zealand. Forest Ecology and Management 258, 2046-2055.
Palmer, D.J., Höck, B.K., Lowe, D.J., Dunningham, A.G., Payn, T.W. 2009b. Developing national-scale terrain attributes for New Zealand (TANZ). Forest Research Bulletin No. 232, 1-81.
Palmer, D.J., Watt, M.S., Höck, B.K., Lowe, D.J., Payn, T.W. 2009c. A dynamic framework for spatial modelling Pinus radiata soil-water balance (SWatBal) across New Zealand. Forest Research Bulletin No. 234, 1-93.
Palmer, D.J., Watt, M.S., Kimberley, M.O., Höck, B.K., Payn, T.W., Lowe, D.J. 2010. Mapping and explaining the productivity of Pinus radiata in New Zealand. New Zealand Journal of Forestry 55 (1), 15-21.
Pronger, J., Schipper, L. A., Hill, R.B., Campbell, D.I., McLeod, M. 2014. Subsidence rates of drained agricultural peatlands in New Zealand and the relationship with time since drainage. Journal of Environmental Quality 43(4), 1442, doi: 10.2134/jeq2013.12.0505
Pryce, T.V. 1997. Distribution and geotechnical properties of Quaternary volcanogenic deposits and soils, Flagstaff North, Hamilton, New Zealand. MSc thesis, University of Waikato, Hamilton.
Pullar, W.A. I 967. Volcanic ash beds in the Waikato district. *Earth Science Journal* 1, 17-30.
Pullar, W.A., Selby, M.J. 1971. Coastal progradation of Rangitaiki Plains, New Zealand. *New Zealand Journal of Science* 14, 419-434.
Robertson, T., Moon, V.G., Lowe, D.J. 2017. Is there a potassium-based solution to sensitive soil slipping within the Bay of Plenty? *In*: Alexander, G.J., Chin, C.Y. (editors), "Proceedings 20th New Zealand Geotechnical Society Symposium", 24-26 November 2017, Napier, 8 pp.
Salter, R.T. 1979. A pedological study of the Kauroa Ash Formation at Woodstock. MSc thesis, University of Waikato., Hamilton.
Scarrow, J.W. 2013. Soil chronosequences and bacterial communities of the central Transantarctic Mountains, Antarctica. MSc thesis, University of Waikato, Hamilton.
Scarrow, J.W., Balks, M.R., Almond, P.C. 2014. Three soil chronosequences in recessional glacial deposits near the polar plateau, in the central Transantarctic Mountains, Antarctica. *Antarctic Science* 26, 1-11.
Schipper, L.A. 2016. Carbon, nitrogen, energy storage in organic matter of pasture soils – and cake. N.H. Taylor Memorial Lecture presented at the joint New Zealand Society of Soil Science and Soil Science Australia conference "Soil, a balancing act Downunder", Queenstown, 12-16 December, 2016.
Schipper, L., Lowe, D.J. 2012. Wai-BOP Soils – a "flash" conference? *New Zealand Soil News* 60, 18-19.
Schipper, L.A., Baisden, W.T., Parfitt, R.L., Ross, C., Claydon, J.J., Arnold, G. 2007. Large losses of soil C and N from soil profiles under pasture in New Zealand during the past 20 years. *Global Change Biology* 13, 1138-1144.

Schipper, L.A., Dodd, M.B., Pronger, J., Mudge, P.L., Upsdell, M., Moss, R.A. 2012. Decadal changes in soil carbon and nitrogen under a range of irrigation and phosphorus fertilizer treatments. *Soil Science Society of America Journal* 77(1), 246-256.

Schipper, L.A., Hobbs, J.K., Rutledge S., Arcus, V.L. 2014a. Thermodynamic theory explains the temperature optima of soil microbial processes and high Q10 values at low temperatures. *Global Change Biology* 20, 3578-3586.

Schipper, L.A., Parfitt, R.L., Fraser, S., Littler, R., Baisden, W.T., Ross, C. 2014b. Soil order and grazing management effects on changes in soil C and N in New Zealand pastures. *Agriculture, Ecosystems and Environment* 184, 67-75.

Schipper, L.A., Mudge, P.L., Kirschbaum, M.U.F., Hedley, C.B., Golubiewski, N.E., Smaill, S.J., Kelliher, F.M. 2017. A review of soil carbon change in grazed New Zealand pastures. New Zealand Journal of Agricultural Research 60, 93-118.

Selby, M.J. 1966. Some slumps and boulder fields near Whitehall. Journal of Hydrology (New Zealand) 5, 35-44.

Selby, M.J. 1967a. Aspects of the geomorphology of the greywacke ranges bordering the lower and middle Waikato basins. Earth Science Journal 1, 37-58.

Selby, M.J. 1967b. The Surface of the Earth, Volume 1. Cassell, London, 272 pp.

Selby, M.J. 1970a. A flume for studying the relative erodibility of soils and sediments. Earth Science Journal 4, 32-35.

Selby, M.J. 1970b. Design of a hand-portable rainfall-simulating infiltrometer, with trial results from the Otutira catchment. Journal of Hydrology (New Zealand) 9, 117-132.

Selby, M.J. 1971a. The Surface of the Earth, Volume 2. Climate, Soils and Vegetation. Cassell, London, 437 pp.

Selby, M.J. 1971b. Runoff, infiltration and soil erodibility studies in the Otutira catchment. DPhil thesis, University of Waikato, Hamilton.

Selby, M.J. 1972. The relationships between land use and erosion in the central North Island, New Zealand. Journal of Hydrology (New Zealand) 11, 73-87.

Selby, M.J. 1973. An investigation into causes of runoff from a catchment of pumice lithology, in New Zealand. Hydrological Sciences Bulletin 28, 255-280.

Selby M.J. 1980. A rock mass strength classification for geomorphic purposes: with tests from Antarctica and New Zealand. Zeitschrift für Geomorphologie 24, 31-51.

Selby, M.J. 1982. Controls on the stability and inclinations of hillslopes formed on hard rock. Earth Surface Processes and Landforms 7, 449-467.

Selby, M.J. 1993. Hillslope Materials and Processes, Second Ed. Oxford University Press, New York, 451 pp.

Selby, M.J., Hosking, P.J. 1971. Causes of infiltration into Yellow-brown Pumice Soils. Journal of Hydrology (New Zealand) 10, 113-119.

Selby, M.J., Hosking, P.J. 1973. The erodibility of pumice soils of the North Island, New Zealand. Journal of Hydrology (New Zealand) 12, 32-56.

Selby, M.J., Pullar, W.A., McCraw, J.D. 1971. Age of Quaternary surfaces near Waihi Beach. Earth Science Journal 5, 106-112.

Seybold, C.A., Balks, M.R., Harms, D.S. 2010. Characterization of active layer water contents in the McMurdo Sound region, Antarctica. Antarctic Science 22(6), 633-645.

Shanhun, F.L. 2005. An investigation of soil moisture associated with ephemeral streams, Wright Valley, Antarctica. MSc thesis, University of Waikato, Hamilton.

Shepherd, T.G. 1984. A pedological study of the Hamilton Ash Group at Welches Road, Mangawara, North Waikato. MSc thesis, University of Waikato, Hamilton.

Shulmeister, J. (editor) 2017. Landscape and Quaternary Environmental Change in New Zealand. Atlantis Advances in Quaternary Science, Volume 3. Atlantis Press/Springer, 334 pp.

Singleton, P.L. 1981. Soil survey of a catchment near Tauwhare. MSc thesis, University of Waikato, Hamilton.

Singleton, P.L. 1991. Soils of Ruakura. DSIR Land Resources Scientific Report 5. Map 1: 5000 + 127 pp.

Soil Survey Staff 2014. Keys to Soil Taxonomy, 12th edition. United States Department of Agriculture Natural Resources Conservation Service, Washington D.C., 360 pp.

Soons, J.M., Selby, M.J. (editors) 1992. Landforms of New Zealand, Second Edition. Longman Paul, Auckland, 531 pp.

Stiles, S. 1998. The distribution of soils on the AgResearch farm at Newstead. BSc(Tech) report EST 264, University of Waikato, Hamilton.

Spinardi, F., Campbell, B., Moon, V., Pittari, A., Fox, B., de Lange, W. 2017. Unravelling fault structures of the Hamilton Basin. *In*: Alexander, G.J., Chin, C.Y. (editors), "Proceedings 20th New Zealand Geotechnical Society Symposium", 24-26 November 2017, Napier, 8 pp.

Takesako, H., Lowe, D.J., Churchman, G.J., Chittleborough, D. 2010. Holocene volcanic soils in the Mt Gambier region, South Australia. *In*: Gilkes, R.J., Prakongkep, N. (editors), Proceedings of the 19th World Congress of Soil Science "Soil Solutions for a Changing World" (1-6 August, Brisbane), Symposium 1.3.1 Pedogenesis: ratio and range of influence, pp. 47-50. Published at http://www.iuss.org/19th%20WCSS/Author_Main.html

Taylor, N.H. 1933. Soil processes in volcanic ash-beds. *New Zealand Journal of Science and Technology* 14, 193-202, 338-352.

Taylor, M.D., Lowe, D.J., Hardi, P., Smidt, G., Schnug, E. 2016. Comparing volcanic glass shards in unfertilised and fertilised Andisols derived from rhyolitic tephras, New Zealand: evidence for accelerated weathering and implications for land management. *Geoderma* 271, 91-98.

Thompson, M.A., Campbell, D.I., Spronken-Smith, R.A. 1999. Evaporation from natural and modified raised peat bogs in New Zealand. *Agricultural and Forest Meteorology* 95, 85-98.

Tonkin, P.J., Lowe, D.J., Nelson, C.S. 2015. Obituary – Emeritus Professor Dr John Davidson McCraw (1925–2014) MBE, MSc *NZ,* DSc *Well*, CRSNZ, FNZSSS. *New Zealand Soil News* 66, 14-35.

Vieira, G., Bockheim, J.G., Guglielmin, M., Balks, M.R., Abramov, A.A., Boelhouwers, J., Cannone, N., Ganzert, L., Gilichinski, D., Goryachkin, S., López-Martinez, J., Mieklejoh, I., Raffi, R., Ramos, M., Schaefer, C., Serrano, E., Simas, F., Slettern, R., Wagner, D. 2010. Thermal state of permafrost and active layer monitoring in the Antarctic: advances during the International Polar Year 2007-9. *Permafrost and Periglacial Processes* 21, 182-197.

Vucetich, C.G., Pullar, W.A. 1964. Stratigraphy of Holocene ash in the Rotorua and Gisborne districts. *NZ Geological Survey Bulletin* 73, Part 2, 43-88.

Walker, M.J.C., Johnsen, S., Rasmussen, S.O. Steffensen, J.-P., Popp, T., Steffensen, J.-P., Gibbard, P., Hoek, W., Lowe, J.J., Andrews, J., Björck, S., Cwynar, L., Hughen, K., Kershaw, P., Kromer, B., Litt, T., Lowe, D.J., Nakagawa, T., Newnham, R.M., Schwander, J. 2009. Formal definition and dating of the GSSP (Global Stratotype Section and Point) for the base of the Holocene using the Greenland NGRIP ice core and selected auxiliary records. *Journal of Quaternary Science* 24, 3-17.

Wall, A. 2004. Use of time domain reflectometry (TDR) to determine moisture and temperature regimes in Antarctic soils. MSc thesis, University of Waikato, Hamilton.

Watt, M.J., Palmer, D.J., Kimberley, M.O., Höck, B.K., Payn, T., Lowe, D.J. 2010. Development of models to predict *Pinus radiata* productivity throughout New Zealand. *Canadian Journal of Forest Research* 40, 488-499.

Webb, T.H. (editor) 1994. Soil-landscape modelling in New Zealand. *Landcare Research Science Series* 5. 173 pp.

Webb, T.H., Lilburne, L.R. 2011. Criteria for defining the soil family and soil sibling, the fourth and fifth categories of the New Zealand Soil Classification (2nd edition*). Landcare Research Science Series* 3. 38 pp.

Wigley, G. 1990. Holocene tephrochronology and evolution of Te Puke lowlands, Bay of Plenty, New Zealand. MSc thesis, University of Waikato, Hamilton.

Williams, P.W. 2017. *New Zealand Landscape – Behind the Scene*. Elsevier, Amsterdam, 470 pp.

Related Society Notices

International Union of Soil Sciences

From the desk of Rattan Lal:

- May Viewpoint: "Soil Degradation: The Case of Human Parasitism" Link here
- April Viewpoint: "The Glamour of Soil Science " Link here

New Zealand Royal Society

The Royal Society is revising its code of Professional Standards and Ethics. Submissions on the revised version have closed, but you can find out more on their website: https://royalsociety.org.nz/who-we-are/our-rules-and-codes/consultation-on-new-code-of-professional-standards-and-ethics/

Global Soil Partnership - International code of conduct for use and management of fertilizers

Following extensive consultation, the latest iteration of an "international code of conduct for use and management of fertilizers" is to be presented to the Global Soil Partnership Plenary Assembly in early June. If endorsed it will be submitted to the FAO "Committee on Agriculture" for review and possible endorsement in September. You can check out the "fertilizer code" at the link: http://www.fao.org/fileadmin/user_upload/GSP/sixth_plenary/ENGLISH/GSPPA_VI_2018_3_e.pdf

Conferences and Training Opportunities

PhD: Carbon sequestration in UK grasslands, SRUC, Edinburgh, UK

A PhD studentship is available at Scotland's Rural College (SRUC) on the topic of sequestration of carbon in UK grasslands. The project title is: "Do UK grasslands have the ability to sequester more carbon? Assessment of stability and resilience to changing climate and management."
For more details, see here. Apply by 28 May.

PhD: Life Cycle Assessment of soil management to fight climate change, Cranfield University, UK

Cranfield University is offering a PhD studentship on consequential Life Cycle Assessment of managing agricultural and forestry systems through increased soil carbon and biochar addition.
For more details and to apply see here. No deadline is specified.

PostDoc: Soil Ecology, University of Adelaide

This role will involve working on a project investigating the impacts of cover crops on soil ecology in viticultural systems in some of Australia's iconic wine regions. The appointee will coordinate field trials, and will be responsible for the sampling and analysis of soil and plant samples. For details see here
Closing date: 15th June

Opportunities at LUKE Finland:

PhD: Biological processes in organic soils

The postdoctoral researcher will focus on sustainability of different forest management options from the soil carbon balance point of view. She/he will work on processes related to carbon and nutrient cycling in organic (peat) soils, mostly forest soils. Apply by 11 June
See the full announcement at www.luke.fi/vacancies and www.valtiolle.fi
ID: 30-285-2018

PhD: Novel cropping systems for sustainable plant production

The task of the postdoctoral researcher is to study the production potential of novel food crops and their traits that are important to generate sustainable production systems for future needs. The main focus is on production potential of the alternative/novel crops, roots, associated soil microbes and other ecosystem services and their interplay in the system. Apply by 11 June
See the full announcement at www.luke.fi/vacancies and www.valtiolle.fi
ID: 30-289-2018

PostDoc: Soil carbon estimation for forestry and agriculture

The postdoctoral researcher will study how land-use affects the quantity and quality of organic matter flows from vegetation to soil in boreal ecosystems. The research approach combines data from ecosystem measurements and satellite observations with mathematical modelling. Apply by 11 June
See the full announcement at www.luke.fi/vacancies and www.valtiolle.fi
ID: 30-288-2018

PostDoc: Land use planning for sustainable bioeconomy
The postdoctoral work has three general objectives: (i) to identify the current land use planning infrastructure that governs the use and protection of renewable natural resources on national, regional and local levels, (ii) to assess the mechanisms with which the social, economic, cultural and ecological impacts are taken into account in bioeconomy land use planning, decision-making and ex post evaluation, and (iii) to provide advice for long-term democratic development of bioeconomy in Finland.
See the full announcement at www.luke.fi/vacancies and www.valtiolle.fi
ID: 30-274-2018

Falling Walls Lab New Zealand. This is an opportunity for innovative thinkers to share, in 3 minutes, their idea, research project, or social initiative from all disciplines, and be in the competition to win a trip to the Falling Walls Lab final in Berlin. Closing date 22 June. More details from Royal Society Te Apārangi.

2018 National Soils Conference, 18-23 November, Canberra, Australia.
Abstracts due 4 June, earlybird closes 27 August.
More details: here

The Sir Hugh Kawharu Masters Scholarship for Innovation in Science.
A $10,000 scholarship administered by Royal Society Te Apārangi supporting and encouraging masters level study by Māori in the sciences. Closing date 1 September. More details here.

2019 International Soils Meeting January 6-9, 2019, San Diego, CA
https://www.sacmeetings.org/

Soil Improvement: Impact of Management Practices on Soil Function and Quality
16 -17 October 2018, Leicester UK
The application of soil improving techniques is crucial to maintain soil functions, long-term productivity and the broad range ecosystem services provided by soils. These techniques include tillage, crop diversity, crop management, cover crops and the use of organic amendments. More information here

17th World Fertilizer Congress of the International Scientific Centre of Fertilizers
3 - 9 September 2018, Shenyang, China
The northeast of China has been traditionally the center of fertilizer production and fertilizer research so that Shenyang was the predestined location to host the 17th World Fertilizer Congress. More information here

ASA National Soils Conference 2018
18 - 23 November 2018 Canberra
The conference will have the theme Soil: The key to past, present and future and we expect that the conference will be a great opportunity for you to showcase your work and to network with your colleagues. There will be significant emphasis on the

practice of soil science. Sponsorship opportunities will be available, and a prospectus will be sent to each member of the society. More information here

2018 NZSSS Conference

3-6 December 2018, Napier, New Zealand
Soils2018 will be held in Napier from 3 to 6 December 2018. This biannual conference is a must attend event organised by the NZ Society of Soil Science and OnCue Conferences, and will cover a range of topics under the theme **'Diverse soils - productive landscapes'.** The wider Hawke's Bay region is home to a diverse mix of primary production, from forestry and sheep and beef production on the coastal and northern hill country, intensive dairy systems on the flat and rolling terraces abutting the ranges, to highly productive horticulture and cropping on the fertile Heretaunga and Ruataniwha plains. During the 4-day conference you'll get a chance to hear from a wide range of researchers, industry leaders, consultants and advisors, regulators and land managers on all things soil-related, anchored by a range of exciting keynotes focused on soilscapes, food production and hot topics around water use and environmental indicators. The conference will be held at the new Napier War Memorial Conference Centre, a great venue on Napier's iconic Marine Parade that looks out on Cape Kidnappers and the city coastline. Centrally located, the NWMCC is across the road from local hotels, restaurants and the downtown shopping precinct. Around the conference you'll have a chance to connect with your colleagues during social activities at some of the Bay's well-known wineries and look at a wide range of offerings from our event sponsors. All of the details about this event can be found at the conference website http://nzssconference.co.nz/. The call for abstracts is now open so please visit the website http://nzssconference.co.nz/call-for-abstracts to see the instructions and submit an abstract. This year we have the following conference themes:

- Macro Influences - Global Food, Water Scarcity, Regulatory Requirements, Climate Change, The Digital Age
- Soil carbon and greenhouse gases
- Soil contamination, degradation and remediation
- Soil biology and ecosystems
- Soil fertility, nutrient management and plant nutrition
- Soil quality and function
- Soil physics and water management
- Use of soils for wastewater/effluent treatment
- Soils in the landscape (Pedology) - Past, Present and Future
- Sustainable management - paddock to catchment scales
- Natural capital and ecosystem services
- Our Land and Water National Science Challenge

If you have any further queries about the science programme please contact Diana Selbie diana.selbie@agresearch.co.nz. Conference registration is open.

Rebecca Withnall and Paul Johnstone, co-convenors
Lea Boodee, On-Cue Conference

Books

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This multidisciplinary book presents state-of-the-art reviews of current SI approaches to promote major food crops, challenges and advances made in technology, and the institutional and policy measures necessary to overcome the constraints faced by smallholder farmers.
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Special Report

AT THE END OF A BALLISTIC MISSILE TRAJECTORY
THE ROLE OF TERRAIN – Norman Wells

The centenary of WW1 has brought up the horrors of the long drawn out warfare on the Western Front, where both sides were entrenched in stalemate, in farmland reduced to a sea of Flanders mud. Important in this was the concept of terrain, meaning the military aspects of landforms and soils, in gaining a mile or two of advantage. Never again, people said when peace came, and WW2 was more mobile, with an increasing role for air warfare, culminating in the deployment of the German V1 and V2 missiles. This is my eye-witness account of the landing of one of Hitler's V2 continental ballistic rockets during the last phase of WW2 in Europe. These missiles were fired from an underground silo near Peenemunde in North West Germany, and were mainly aimed at London. Of the five landings close to me, this one, in daylight, showed most clearly how the local topography and soil conditions could influence the missile's effect, and consequently one's chance of survival.

Come with me on a suburban electric train from Woolwich Arsenal station to Charing Cross in central London. I am attending a morning lecture in physics, but on the way will have an unexpected demonstration, of the relative speeds of light, blast and sound. Our train waits in the station, with adjustable windows wide open, as mandated, and non-opening windows plastered with sticky tape. With rush hour over, there are very few mid-morning passengers; unnecessary travel is officially discouraged, and with these new unpredictable weapons people might prefer to be blown up at home rather than on the move.

I make for the front compartment, the best option for a quick exit at Charing Cross. I found the strong wind through the open window quite acceptable, but the only other occupant, a man reading his newspaper, is sitting in the middle with his back to the engine, to minimise draughts. As customary, we do not invade privacy by speaking to one another.

The train starts on time and winds its way round the near-slum area near Woolwich Dockyard. It was here that Henry VIII had galleons built, which were then drifted down on the tide to Woolwich Arsenal, where they were fitted out with cannon, shot and gunpowder, and were the basis of the fleets which first defended England against European powers, then secured the growing number of colonies that became the British Empire. The Arsenal itself was now the focus of air attack, and after the damage from five V2 rocket strikes in the last months of the war was never rebuilt.

Our train travels from Woolwich, a borough which received over 35 V2 rockets, to Greenwich, which received 10 fewer, both numbers high compared with other areas of London. The train track into central London at this point cuts through the steep wooded hill at Maryon Park, then goes by waste land between a high grassy terrace and the commercial waterside areas near the Thames. Surprisingly, no houses are visible from this side of the train. The uneven low-angled slope to the terrace indicated land instability. I was gazing idly at this terrace edge when a V2 arrived directly in my line of sight. It landed behind the terrace, falling well short of its target of dockland and industry.

The actual landing was too fast to be seen, but the intense white flash of the explosion started a sequence that lasted no longer than a second. The blast wave followed immediately, entering our compartment through one open window and exiting on the other side. The man opposite me still had his hands outstretched, but his newspaper had gone out of the window towards the Thames. The train driver, looking forward, may not have seen the flash, but he felt the blast and activated the emergency stop. Up in the park the explosion on landing had sent the rocket's casing back up into the sky. It started white hot, which faded to a silver colour as it cooled and began to flutter in pieces back to earth. Before the train could come to a halt there was a sound as if an express train was running right over us; this was the rocket's arrival, and faded fast, as the sound travelled from the higher levels of the trajectory. The irony was, when we heard it coming, we had already survived the danger. Our lightly loaded train shuddered to a halt. I poked my head out of the window to see if the rest of the train was still there, which only a few other passengers bothered to do; most people would simply sit there, happy not to know the details of what had happened, simply that the bomb, missile, or whatever had not "had their name on it", as the stoic phrase went. The train driver got down from the engine, walked a few paces away to look back slowly, coach by coach, down the train. The guard at the other end placed the red flag in its holder, also got down and looked slowly up the train. When their line-of-sight met they exchanged swear words, then the guard shrugged his shoulders, climbed back in to his van, removed the red flag and waved the green flag. The Cockney driver spoke to his engine, "Let's git outta 'ere." With few passengers to get off and on, we made it to Charing Cross on time. I went to my lecture, then told my story to fellow students over a sandwich lunch. For background music they played me the gramophone record of Wagner's Ride of the Valkyries.

Why did we and our train escape so lightly from the missile explosion? The precaution of open train windows helped to reduce the impact of the blast wave. The V2 was designed to do maximum damage to the built environment, to destroy concrete and brick buildings. Directly it hit something hard it detonated to optimise the horizontal component of the blast. When our missile landed on a soft soil surface the detonation was delayed a fraction of a second while pressure built up on the penetrating nose cone. This delay meant that the explosion took place partially below ground surface, minimising the horizontal component of the blast but enhancing the vertical component. The train track ran about 50m below terrace level, a position also reducing blast on the train. The records appear to link only one death to this incident, by heart attack from stress, in a house nearby. By contrast, when a similar missile hit the neighbouring New Cross shopping area in November 1944, 168 deaths were reported. Missiles landing on very soft terrain, such as mudflats and marshes, sometimes shed their rocket casing but buried the warhead still unexploded. Reports of these hazardous finds went on for years.

The arrival of the V2 rockets on London changed the character of warfare, no longer aimed at armies but at infrastructure. Shooter's Hill, where I lived, was equipped for war from the air as we had known it, with barrage balloons, searchlights and rocket guns, and even for a land battle, had the threatened invasion taken place. With the advent of the V2 all the anti-aircraft weaponry was useless, sirens could give no warning, and the civilians had to become inured to death as a bolt from the blue. Warfare no longer depended on clever strategy and brave men, but was remotely-

executed destruction of infrastructure, with civilian casualties as collateral damage. A sustained attack of this kind might have been hard to withstand, but the Allied Army of the Rhine closed down the German launching sites in early 1945, and took the technology and some of the engineers to construct Inter-Continental Ballistic Missiles in the USA. Other nations now have the technology.

These larger ballistic missiles would probably override the factors of topography and of soil strength that saved our train from the V2 rocket. Ballistic missiles combined with miniaturised atomic warheads are steps on the way to Mutually Assured Destruction, and, if nothing worse, a huge setback for mankind.

Abstracts

Soil cadmium and New Zealand dairy farms: Impact of whole-farm contaminant variability on environmental management

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Abstract: Two long-term dairy farms with different phosphorus (P) fertiliser application history in the North and South Island of New Zealand were studied to understand factors influencing the spatial distribution of soil cadmium (Cd). Intensive soil sampling within each farm showed that soil Cd concentrations (0–150 mm depth) were much greater and more variable in the Waikato (North Island) farm (mean: 1.04 mg kg^{-1}, range: 0.48–1.64 mg kg^{-1}) than the Canterbury (South Island) farm (mean: 0.34 mg kg^{-1}, range: 0.15–0.64 mg kg^{-1}). A significant ($P < 0.001$) relationship between total soil Cd and total P indicated the overriding influence of P fertiliser application history on soil Cd accumulation. However, within land management units (LMUs) of common P fertiliser history, soil type had a significant ($P < 0.001$) influence on soil Cd concentration. Slope class had no influence ($P = 0.491$) on soil Cd concentration within the range of 0–15°. There was no clear, consistent relationship between soil Cd and land-based effluent disposal on either farm. Given the large spatial variability in soil Cd concentration that was evident within the two farms of this study, it is recommended that sampling strategies used for the assessment of soil Cd (e.g. under environmental regulation/management frameworks) need to account for variation in land use, P fertilisation history, and soil type. Sampling individual paddocks based on predominant soil type will also allow areas to be identified where there is heightened risk of plant Cd accumulation.

Stafford, A.D., Palmer, A.S., Jeyakumar, P., Hedley, M.J., & Anderson, C.W. (2018). Soil cadmium and New Zealand dairy farms: Impact of whole-farm contaminant variability on environmental management. *Agriculture, Ecosystems & Environment*, 254, 282-291, https://doi.org/10.1016/J.AGEE.2017.11.033

Soil Repellency-induced runoff from New Zealand hill country under pasture: A plot study

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Abstract: Soil water repellency is a common phenomenon which develops when surface soils become dry in summer and autumn. It is claimed that repellency is likely to result in a lower infiltration rate and a concomitant increase in surface runoff, particularly on slopes. This study quantifies the effect of water repellency on runoff from a series of small plots on a range of slopes (20° and 30°) and aspects (N, S and E) in a hilly landscape in the south-east of the North Island of New Zealand. The plots (1 m wide and 2 m long) were set up to capture runoff via a slotted PVC pipe and measure it using tipping bucket apparatus: at each of the slope/aspect locations there were duplicate plots. A meteorological station was also established at the site along with TDR probes to measure soil moisture down to 300 mm depth. When moist, the soil at the site had a very high infiltrability (>1.5 mm/min). On nine occasions, runoff was measured (ranging from 1 to 59% of rainfall) when the soil surface was dry and rainfall was intense (greater than 0.1 mm/min). However, during the two-year study period, this repellency-induced runoff equated to only 5% of the total rainfall. Furthermore, the infiltration rate of initially dry, repellent soil (ranging from 0.2 to 0.6 mm/min) partly recovered over a ten-minute period (0.6–1.0 mm/min) and, with sufficient rainfall, repellency completely disappeared within two days. The transitory nature of water repellency was confirmed in an experiment on large soil slabs conducted in the laboratory where repellency-induced runoff was observed to largely disappear over a period of 30 min. Overall, it is concluded that soil water repellency does not play a major role in the soil water balance of the hill country at the study site.

Bretherton, M., Horne, D., Sumanasena, H.A., Jeyakumar, P., & Scotter, D. (2018). Repellency-induced runoff from New Zealand hill country under pasture: A plot study. *Agricultural Water Management*. 201, 83-90, https://doi.org/10.1016/j.agwat.2018.01.013

Influence of Soil Moisture Status on Soil Cadmium Phytoavailability and Accumulation in Plantain (*Plantago lanceolata*)

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Abstract: The effect of fluctuating soil moisture cycles on soil cadmium (Cd) phytoavailability was investigated in a pot trial with two contrasting soils (Kereone (Allophanic), total Cd 0.79 mg kg^{-1}; and Topehaehae (Gley), total Cd 0.61 mg kg^{-1}) that were either sown with plantain (*Plantago lanceolata*) or left unseeded. Varying soil moisture contents were established using contrasting irrigation regimes: “flooded” (3 days flooded and then 11 days drained); or “non-flooded” (irrigation to 70% of potted field capacity every 7 days). Overall, there was no significant difference in mean 0.05 M $CaCl_2$ soil extractable Cd concentrations or plant tissue Cd concentrations between flooded and non-flooded irrigation. However, there was a consistent trend for an increase in soil extractable Cd concentrations following irrigation, regardless of the irrigation regime. Mean soil extractable Cd and plant

tissue Cd concentrations were significantly greater (approximately 325% and 183%, respectively) for the Topehaehae soil than the Kereone soil, despite the lower soil total Cd concentration of the Topehaehae soil. These results indicate that Cd solubility is sensitive to increases in soil moisture following periods of soil drainage, but insensitive to short-term periods of soil saturation. Plant tissue Cd concentrations in Cd-sensitive forage crops such as plantain are likely to be greater following large rainfall events over summer and autumn. This has the potential to increase animal dietary Cd exposure and rate of liver/kidney Cd accumulation.

Stafford, A.D., Jeyakumar, P., Hedley, M.J., & Anderson, C.W. (2018). Influence of Soil Moisture Status on Soil Cadmium Phytoavailability and Accumulation in Plantain (*Plantar lanceolata*). *Soil Systems*. 2(1), 9, https://doi.org/10.3390/soils2010009

Soil cadmium and New Zealand dairy farms: Impact of whole-farm contaminant variability on environmental management

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Abstract: Contamination of soil and water with fluorine (F) leached from phosphogypsum (PG) stacks is a global environmental issue. Millions of tons of PG is produced each year as a by-product of fertilizer manufacture, and in China, weathering is exacerbated by acid rain. In this work, column leaching experiments using simulated acid rain were run to evaluate the mobility of F and the impact of weathering on native bacterial community composition in PG. After a simulated summer rainfall, 2.42-3.05 wt% of the total F content of PG was leached and the F concentration in leachate was above the quality standard for surface water and groundwater in China. Acid rain had no significant effect on the movement of F in PG. A higher concentration of F was observed at the bottom than the top section of PG columns suggesting mobility and reprecipitation of F. Throughout the simulation, the PG was environmentally safe according the TCLP testing. The dominant bacteria in PG were from the Enterococcus and Bacillus genus. Bacterial community composition in PG leached by simulated acid rain (pH 3.03) was more abundant than at pH 6.88. Information on F mobility and bacterial community in PG under conditions of simulated rain is relevant to management of environmental risk in stockpiled PG waste.

Wang, M., Tang, Y., Anderson, C.W.N., Jeyakumar, P., & Yang, J. (2018). Effect of simulated acid rain on fluorine mobility and the bacterial community of phosphogypsum. *Environmental Science and Pollution Research*, 1-13, https://doi.org/10.1007/s11356-018-1408-5

Cadmium in soils under pasture predicted by soil spectral reflectance on two dairy farms in New Zealand

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Abstract: In this study, visible and near-infrared reflectance spectroscopy (NIRS) was used to predict variation in total carbon (C), total nitrogen (N) and total cadmium (Cd) concentrations with soil depth. Soil cores were collected intact to 400–600 mm depth from two long-term dairy farms with contrasting soils, phosphorus (P)-fertiliser and land management history. Specific to each farm, a partial least squares regression (PLSR) model was developed to calibrate spectral reflectance data against total C and total N measured within 50 mm soil core depth increments. The resultant predictive models were able to successfully predict total soil C (R2 = 0.91–0.95, RMSECV (%) = 0.40–0.64, RPD = 3.41–4.33) and total N concentrations (R2 = 0.91–0.92, RMSECV (%) = 0.04–0.08, RPD = 3.43–3.57). In both farms there was a strong correlation (R2 = 0.83–0.90) between laboratory-measured total soil Cd and total C or total N. Based on this relationship, total soil Cd concentration was predicted from NIRS-predicted total C (NIRS-C) and/or total N (NIRS-N) concentrations. Soil profile total Cd concentrations and variation with depth was similar for measured and NIRS-C and/or NIRS-N predictions, although relationships between total Cd and total C or total N are site specific and non-transferable. Overall, NIRS shows promise as a rapid in-field diagnostic tool, allowing low-cost paddock-specific assessment of total soil C/N concentrations. This information will be useful to understand tillage history, and consequently may lead to a rapid assessment method for interpreting variation in soil total Cd concentrations between paddocks and with soil depth.

Stafford, A.D., Kusumo, B.H., Jeyakumar, P., Hedley, M.J., & Anderson, C.W. (2018). Cadmium in soils under pasture predicted by soil spectral reflectance on two dairy farms in New Zealand. *Geoderma Regional*. 13, 26-34, https://doi.org/10.1016/j.geodrs.2018.03.001

Why copper and zinc are ineffective in reducing soil urease activity in New Zealand dairy-grazed pasture soils?

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Abstract: Micronutrients copper (Cu) and zinc (Zn) have the potential to inhibit soil urease activity (UA) and reduce ammonia (NH_3) emissions over a longer duration (8–12 weeks) but these have not been tested for reducing NH_3 losses from cattle urine deposited in dairy-grazed pasture soils. The objective of this study was to assess the effectiveness and longevity of Cu and Zn in reducing soil UA, for the use of these metals to reduce NH_3 emissions from deposited urine by grazing cattle. A series of experiments were conducted to i) assess the relationship between inherent Cu and Zn status and soil UA of New Zealand (NZ) dairy-grazed pasture soils, ii) determine the impact of Cu and Zn addition to pasture soils on soil UA, and iii) investigate how soil organic carbon (C) and other C related textural and mineralogical properties such as clay content and cation exchange capacity (CEC) influence the effectiveness of added Cu and Zn in reducing urea hydrolysis. The results showed a significant positive correlation of soil total C and total nitrogen (N) with soil UA. But there were no significant negative correlations between soil UA, and inherent Cu and Zn levels. Similarly, addition of Cu and Zn to soil did not significantly reduce soil UA. However, when Cu was added to two different soil supernatants there was a significant reduction in hydrolysis of urea applied at 120 and 600 mg urea-N kg^{-1} soil. Additions of Zn achieved a negligible or small reduction in urea hydrolysis after 120 and 600 mg urea-N kg^{-1} soil applications to soil supernatants. This result suggests that Cu can inhibit soil UA and urea hydrolysis in soil supernatants with potentially low C, clay and cation exchangeable base contents. However, the interaction of bioavailable Cu with labile soil organic C and clay particles leads to its inactivation resulting in ineffectiveness in organic C-rich pasture soils. Although most of the added Zn did not complex and remained bioavailable, the observed levels of bioavailable Zn had limited effect on studied soil UA.

Adhikari KP, Saggar S, Hanly JA, Guinto DF, Taylor MD, (2018) Why copper and zinc are ineffective in reducing soil urease activity in New Zealand dairy-grazed pasture soils? *Soil Research*.

Geoderma. https://doi.org/10.1016/j.geoderma.2018.05.006\ Geoderma 328:44-55.

An investigation of organic matter quality and quantity in acid soils as influenced by soil type and land use

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Knowledge of the molecular composition of soil organic matter (OM) and the interaction of OM with soil minerals is needed to fundamentally understand how the persistence of OM is affected by land use. We investigated organic carbon (C) fractions, content of short-range order constituents (SRO) (i.e., Al and Fe oxy-hydroxides) and OM chemistry of 45 top soils across a range of soil orders and land

uses in New Zealand. The objective of the study was to assess the influence of different land uses on the OM quality and quantity of soils that differed in their content of SRO constituents. The C fractions considered were cold+hot water-soluble C (C_{H2O}), C recovered in the residuum after HF treatment ($C_{HF\text{-}residuum}$), and C not so recovered ($C_{HF\text{-}mobile}$). Carbon in particulate OM (C_{POM}) was determined in non-Allophanic soils, and C extractable with sodium pyrophosphate (C_p) in Allophanic soils. The chemistry of the HF-residual OM was investigated using pyrolysis-GC/MS. The highest C content was found under grazed grasslands and, among soil orders, in Allophanic soils, which had the largest $C_{HF\text{-}mobile}$ and $C_{HF\text{-}residuum}$ contents. Yet compared to non-Allophanic, Allophanic soils were more vulnerable to loss of C ($C_{HF\text{-}mobile}$ and $C_{HF\text{-}residuum}$) when used for cropping. The relative contribution of microbial- vs. plant-derived OM was influenced by soil order and land use: microbial-derived OM increased as the presence of SRO constituents increased, these being more abundant in Allophanic soils; soils under ungrazed grasslands had the largest contribution of fresh plant-derived molecules to OM (and of $C_{HF\text{-}residuum}$ to total C) while cropping had a negative impact on the contribution of plant-derived OM, consistent with a decrease in C_{POM}. Overall, the results showed that not only is the ability of New Zealand soils to store C soil-specific, but so too is their vulnerability to losing it when under specific land use.