POSTER ABSTRACTS

IN ORDER OF PRESENTERS LAST NAME

Environmental management perspectives of soil fluorine in New Zealand's agricultural soils

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The prolonged use of superphosphate fertilisers has inherited an accumulation of F in topsoils and it is considered to be building up in most of New Zealand's agricultural soils. New Zealand research into soil F has been hampered by the lack of a reliable and simple test for soil F. The accuracy of different methods to quantify the presence of F in analytical preparations is dependent on interfering elements such as aluminium (Al). The conventional methodology of NaOH fusion is considered to be time consuming, expensive and very dependent on the abilities of the operating technician, thus it is not ideal for environmental monitoring. A study conducted at FLRC, Massey University, to assess the accuracy of alternative techniques relative to the standard fusion protocol found that simple extraction of soil with NaOH (4M) consistently reported 80% of the total soil F for Allophanic soils, which generally represents the greatest history of build-up of soil F from superphosphate application. This initial work was further examined to confirm the repeatability of the NaOH extraction technique to quantify soil F, with specific focus on the relative accuracy of this technique between different soil orders. In order to have a representative wide range of soil orders and long-term fertiliser application background, a study was conducted to perform the NaOH extraction technique on 13 different New Zealand soil types to determine the distribution of total soil F. This technique was further validated by analysing in both New Zealand and Australian laboratories. Variability between soils was assessed as a function of soil properties. Using this method, a controlled laboratory study was then performed to assess the impacts of elevated F on soil microbial activity. This presentation proposes the environmental guidelines to reliably measure and manage the elevated F issues in the New Zealand agricultural system.

Calibrating weathering functions from hillslope soils

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Quantifying rates of weathering is important for understanding and modelling the biogeochemistry of important nutrient elements. To date, time-dependent weathering functions have been calibrated experimentally or by using soil chronosequences. However, applying weathering functions to hillslope soils is problematic because such soils do not have a well-defined soil age; instead, soils on hillslopes are made up of an ensemble of particles of different age, determined by their time of release from the soil parent material below the soil and all points upslope. The theoretical gap is significant because hillslopes and hillslope soils dominate the Earth's surface and we need a framework for assessing the controls on mineral weathering and nutrient supply. In this poster we present a theoretical treatment of chemical weathering, assuming steady state hillslope soils, and weathering described by a power law function of particle age. We apply the theory to the calibration of a weathering function for apatite P for the extreme weathering and soil production environment of the western Southern Alps. The analysis predicts the kinetic limitation of apatite P weathering at high soil production and erosion rates, and suggests an optimum soil production (and erosion) rate for ecosystem P supply. The theory may be applied to any soil mineral or element, but relies on a minimum data set for calibration; namely, soil production rate, soil depth, chemical depletion factor (determined from a stable element, e.g. Zr), element concentration in the parent material and the soil, and soil and bedrock bulk densities.

Evaluating wheat genotypes tolerant of sodic soil

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In sodic soils, crop yield suffers due to physical and chemical constraints. Identification of sodicity tolerant genotypes is one of the options to improve productivity of these soils. In this project, sodicity tolerance of 36 wheat genotypes widely grown in Australia was assessed at two sites: a control (low sodicity site, ESP=3) and a sodic site (ESP=6) situated near Billa Billa, southern Queensland, during 2015. Both the sites contained similar pH range (surface soil >8.0, subsoil <6.5), electric conductivity (0.2–0.3) and other nutrients (Cl and N-NO3). This study aimed to characterize wheat genotypes that would possess combined tolerance to physical and chemical constraints encountered in sodic soils. Emergence, soil moisture content, nutrient uptake in leaves, biomass, hyperspectral reflectance, and LiDAR data were correlated with grain yield. The grain yield varied significantly among different genotypes at both sites. Due to unusually favourable timing of rainfall, the detrimental effects of sodic soil were reduced. The average yield for all genotypes was 9.5% higher on the sodic soil than the control. Some genotypes (e.g. Flanker) had higher grain yield on the sodic soil than the control. Index leaf analysis at anthesis indicated that genotypes with higher concentrations of Na+ in their leaves had lower yield than other genotypes in both paddocks. Particular genotypes maintained higher concentrations of potassium in index leaves in sodic soil than the control, e.g. Hartog. The control paddock had a higher proportion of undersized grain (screenings) than the sodic. Relating biomass at anthesis with hyperspectral data produced moderately high prediction accuracy, correlation (r2) values ranging from 0.5 to 0.6. With regards to yield, the partial least squares (PLS) regression results show that hyperspectral data are useful in yield prediction. The PLS models produced high correlation values (r2=0.586 to r2=0.755), particularly for data collected during the anthesis stage.

Effect of compost application on soil composition

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This project assessed compost application to a range of soil/land uses in the Tweed Valley of NSW. The project was funded by the Australian Government and Tweed Shire Council.
There were six land use types: sugar cane, sweet potato, vegetables, beef, dairy and perennial tree crops (nut tree, avocado, banana). The number of 'replicates' properties within each land use type ranged from 4 to 6. All 30 properties had three adjacent plots. The plots received 0, 10 or 20T/ha of wet compost/ha. The 30 landholders used the most readily available local compost derived from products such as municipal green waste and dairy effluent. This resulted in a range of compost compositions and moisture contents reflecting realistic farm practices.
Trial sites were sampled prior to treatment in 2012, and, after 3 years of compost application, in 2015. Sampling consisted of 12 composite samples for 0–10cm from the three trial plots on each farm. In 2015 all 90 plots were sampled. Soil attributes measured include major cations, effective Cation Exchange Capacity, pH (5:1 water:soil), lime requirement (kg/ha), salinity (sat. paste) and micro nutrients including B, Co, Cu, Fe, Mn, S, Si, Se and Zn. Extraction techniques were generally based on Rayment and Lyons (2011).
The land use/soil type combination was the major determinant of soil chemistry irrespective of compost type or application rate. Soil pH, Ca:Mg ratio, Ca as % of ECEC, and ECEC all increased significantly (P<0.05) with compost application rate. Other nutrients showed a similar trend but the difference was not significant. For example, B increased from 0.64 to 0.79mg/kg with increased compost application. This change had a 90%ile probability of being 'real'.
The results indicate that compost addition can influence a wide range of soil chemical attributes.

Gas emissions from an intensive vegetable farm measured with slant-paths FTIR technique

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An open-path Fourier transform infrared (OP-FTIR) spectroscopy system was deployed in a modified flux gradient (FG) technique to give open-path line-average concentrations from vertically separated slant-paths. Fluxes of ammonia (NH3), nitrous oxide (N2O), carbon dioxide (CO2), and methane (CH4) were measured simultaneously following chicken manure application to a vegetable farmland in autumn for three weeks. The FG/OP-FTIR technique detected the temporal variability in all gas fluxes during the experimental period, and NH3 emissions showed the quickest response to manure addition, increasing substantially within six days. In contrast, fluxes of CO2 and CH4 strongly correlated to N2O emissions (R2>0.5), and respected to air temperature and precipitation events. Daily emission rates of NH3, N2O, CH4, and CO2 (mean ± SE) were 10.9 (±0.6), 6.9 (±0.5), 23.6 (±3.8) mg m-2 h-1, and 4.2 (±0.9) g m-2 h-1, respectively. We extrapolated these results to the national vegetable industry across Australia, and found that fertilized/irrigated vegetable lands contribute 34.2% of agricultural sector emissions, and 5.1% of national GHG emissions. The latter is comparable to a previous estimate of 5%.

Slow- and fast-release boron in a potassium macronutrient fertilizer

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Boron (B) is an essential micronutrient required by plants during all growth stages from seedling to flowering. A challenge of B fertilization is to provide adequate B throughout the season, even in high rainfall environments, without reaching levels too high causing toxicity at sowing. The most common B fertilizers are highly water soluble, resulting in leaching followed by deficiency later at flowering. A second challenge is to provide a uniform spread of the relatively small amounts of B required over a wide area to ensure efficiency of supply to plants. This paper describes a range of fertilizers with slow- and fast-release B in different ratios designed to address these challenges. Borax, ulexite and colemanite with water soluble B varying between 100% and 22% were used in a co-compacted MOP (Muriate of Potash) fertilizer to produce MOP with 0.5%B. The B in the fertilizer was evenly distributed throughout the macro MOP matrix, providing a uniform spread of B when applied to the soil. The kinetics of B release were determined using a column dissolution method, which showed the products release firstly the highly soluble B, followed by a prolonged slower B release. The spatial variability of the fertilizer B was assessed in incubated soil trays, which showed minimal variation for the co-compacted product, while a blend of MOP with borax showed B concentrations in the toxic range around the borax granule and deficient concentrations elsewhere. Finally, in a pot trial with simulated rainfall, B uptake by canola was higher for MOP compacted with a slow-release B source (colemanite) than for MOP compacted with borax only. These results demonstrate the usefulness of slow release B fertilizer, particularly in high rainfall areas.

A preliminary assessment of the CMD Mini-Explorer for assessing soil salinity

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The CMD Mini-Explorer is a relatively newly available multi-depth electromagnetic conductivity meter. At two kilograms, it is a lightweight, user friendly and robust piece of field equipment. The unit is also less expensive to purchase than other similar devices currently on the market. The unit provides apparent EC (expressed as mS/m) of the soil in depth slices attenuating at approximately 25, 50, 90, 100 and 180cm, with three depths being assessed during a single pass. It was used to assess the salinity of a pastured paddock in the process of being irrigated with moderately saline coal seam gas water of approximately 5mS/cm. The water was being applied using a network of surface drippers, with the wide spacings between dripper lines resulting in a mosaic of saturated and dry soil. Ten locations of varying inundation were assessed using the CMD Mini-Explorer using the 25cm depth setting, and then the soil was sampled to 0–20cm depth below ground surface. The samples were assessed for moisture content and electrical conductivity from a one-to-five soil water solution extract (EC1:5). An 85% r-square was determined between the measurements of the unit and the oven dried moisture content. An 86% r-square was determined between the measurements of the unit and the EC1:5. When these two factors were combined, the r-square with the unit improved to 92%.

Effect of crop rotation on mycorrhizae formation, WUE and wheat yield under different fertiliser treatments

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Crop rotation and fertiliser application are essential management practices for improving soil quality. Preceding crops can affect the growth and yield of subsequent crops not only by changing the nutrient status of the soil but also by changing the soil microbial community, including mycorrhizal fungi. Two wheat genotypes (249 and a CIMMYT line) were planted after crop rotation with canola or chickpea with different nitrogen and phosphorus fertiliser treatment (0 and 100kg N ha-1 and 0 or 20kg P ha-1) in the field. Crop rotation and fertiliser treatment effects on yield and leaf δ13C (a proxy for water use efficiency) were examined. The percentage of roots colonized by arbuscular mycorrhizae fungi was determined and related to soil-available N and P, proportion of fine diameter roots, yield and leaf d13C. Crop rotation had no effect on soil-available N and soil-available P. However, mycorrhizal infection in wheat was substantially higher after chickpea than after the canola rotation (on average 60% higher). Wheat yield after the chickpea rotation also increased, particularly for the CIMMYT line. While soil-available N and P were not related to yield, we observed significant relationships between mycorrhizal infection and yield for both genotypes. In contrast, both N and P fertiliser application reduced mycorrhizal infection and yield, but increased plant biomass and leaf tissue N and P concentrations. Possibly, mycorrhizal infection reduced water stress in wheat as suggested by the observed negative relationship with leaf d13C, particularly in the 249 line. Mycorrhizal infection was further related to the proportion of fine roots, suggesting that fine roots are conducive to mycorrhizal infection. We conclude that cultivation of crops (e.g. chickpea) in the previous season that can enhance mycorrhizal infection of wheat roots may reduce water stress and increase grain yield.

Management of pasture termination can reduce soil nitrous oxide emissions in high rainfall cropping systems of South Eastern Australia

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Nitrous oxide (N2O) is a potent greenhouse gas. Agriculture accounts as the biggest contributor to the anthropogenic global N2O budget. Emission of N2O also represents a loss of valuable plant-available nitrogen from the soil. For these reasons, there is a growing interest in quantifying losses of N2O from agricultural soils and developing practical strategies for reducing N2O losses.

This two-year field experiment evaluated the effect of conversion of long-term pasture to arable cropping on N2O emissions in the high rainfall zone (HRZ) of south-west Victoria. Early termination (pasture terminated 6 months prior to sowing) followed by winter (ETw) and spring (ETs) crops and late pasture termination (pasture terminated one month before sowing) followed by a winter crop (LTw) were compared with continuous mown pasture (MP). Emissions of N2O were measured continuously using the automated gas sampling and analysing system.

Emissions from MP were low throughout the study, resulting in annual losses of 0.13kg ha-1 N2O-N ha-1. In the first year, annual losses from ETw and ETs plots were 7.1kg ha-1 and 3.6kg N2O-N ha-1 respectively, while only 0.6kg ha-1 was lost from the LTw treatment. This trend was still noticeable in the second year of the study. High emissions were associated with N mineralisation and the accumulation of NO3-N in the soil during the extensive fallow period after early pasture termination or wheat harvest. Soil water content was a key factor influencing the temporal fluctuations in N2O emissions. Low emissions occurred when water-filled pore space (WFPS) was less than 30% while high emissions occurred when the WFPS was above 65%, suggesting that denitrification was the major source of N2O emission. Applying late rather than early pasture termination, and thus reducing the length of the fallow period, is a practical way of reducing N2O emissions from mixed pasture/cropping systems.

Co-composting of urban biochar with food waste decreases its efficacy as a soil amendment

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A composting experiment was conducted to artificially age biochar where food waste was composted alone and also with 10% urban biochar (UB) produced from urban wastes (2:1 ratio of biosolids and green waste) for 10 weeks. UB was also placed in litterbags inside compost mix to assess changes in biochar due to composting. Co-composting UB with food waste accelerates the composting process and increases biochar CEC, pH, EC and nutrient loading; however, this co-composting process also reduces the surface area and porosity of UB. To assess the agronomic value of the finished composts, those composted materials were mixed at the rate of 10% (V/V) with top soil of Semiaquic Podzol for a greenhouse experiment where sorghum plants were grown and plant performance was assessed along with weekly gaseous emissions. Results of the greenhouse experiment showed higher plant growth, lower emission of N2O and higher plant nutrient uptake in soil amended with fresh urban biochar than compared to co-composted biochar treatment.

Soil test interpretation information to assist decision making on farms

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A recent soil-health project in the Goulburn Broken Catchment focused on helping farmers to interpret their soil-test results, and to understand the management implications for on-farm decision making. The idea for this 'mini' extension project came from a member of one of the active Landcare groups in the catchment.

There has been a long history of soil-health extension in the catchment that has encouraged soil testing, liming acid soils and managing pastures to maintain appropriate levels of ground cover. Despite this long extension history and the plethora of resources now available online, many farmers find soil tests complex, difficult to understand, and are not confident in converting the soil test numbers to a practical on-farm decision.

The project developed an easily accessible farmer resource, written in lay terms – a 56-page, coil-bound booklet titled *Understanding your soil test: step by step*. A collaborative writing process was used, involving farmers, extension practitioners and soil scientists. A soil-test interpretation workshop was developed to launch the resource.

The first print run of 2000 copies was taken up within the first four months of its release, prompting a reprint of 2000. The original workshop to launch the resource was oversubscribed and three more were run to satisfy demand. Two liming workshops were conducted in response to participant feedback.

These results were unexpected. Semi-structured interviews were used to follow up both participants of the workshops and people ordering multiple copies of the booklet resource from outside the catchment and state. The interviews explored perceptions of the extension practices used and the impact on farmer decision making.

We have learnt more about the challenges farmers face understanding complex soil-test results and the implications for on-farm decision making, often involving large financial inputs and risk.

This paper explores the lessons learnt from this project for extension practice.

Soil water repellency on a hill country Pumice soil: Implications for pasture management

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During prolonged dry periods, soil water repellency (SWR) develops under permanent pasture in many areas of New Zealand. This is a hallmark characteristic of many hill country pastures, particularly on the East Coast of the North Island, where pasture production is frequently limited by large soil water deficits during summer and autumn. As SWR compromises soil infiltrability, summer and autumn rainfall is often channelised into overland flow, thereby reducing pasture-effective rainfall and increasing the risk of losses of nutrients, sediment and faecal material to water bodies.

This study examines SWR on a Pumice soil on a hill country sheep and beef farm in Northern Hawke's Bay. A series of plots (4 × 3m) were placed on a range of sites on a northeast-facing aspect with slopes ranging from 25–30 degrees. For comparison, some plots were placed in landscape positions where channelised and sub-surface flow was likely. SWR, soil moisture, climate variables, and pasture production were monitored over several months in early 2016.

Temporal and spatial in situ hydrophobicity persistence (as measured by the water droplet penetration test) was observed and ranged from less than 1 second to more than 30 minutes.

An attempt is made to link monitored variables together and to help validate the use of a SWR-modified soil–water balance model.

Determining nutrient release from slow-release fertilizers through electrical conductivity measurements

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Slow-release fertilizers may increase nutrient use efficiency and minimize environmental impacts, particularly for nitrogenous fertilizers. Basically, two major groups of slow-release fertilizers can be distinguished: low solubility products and, more commonly, use of coatings on soluble products. The coating acts as a physical barrier, which either requires diffusion of the nutrient through the coating or disintegration of the coating for the nutrient to be released. Methods to determine the release of nutrients usually rely on chemical analyses, which often are time-consuming and/or expensive. We developed an easy method to measure release of nutrients from slow-release fertilizers through determination of the electrical conductivity (EC), which is a fast, inexpensive and reliable measurement. The release of nutrients from the granules in water is determined by measuring the EC at different times depending on the release rate. In the case of ionic fertilizers (e.g. phosphate, ammonium or nitrate fertilizers), the EC can be immediately determined and is converted to a concentration based on a product-specific calibration curve. In the case of urea, an additional step is needed to convert the neutral urea molecule to charged ions by adding urease to a subsample, which is left to equilibrate after which the EC is determined. Preliminary experiments were carried out to determine the concentration of urease needed to attain near full hydrolysis of urea within one hour. Nutrient release rates in water were assessed for a range of commercial and laboratory-coated fertilizer products. For some phosphorus (P) fertilizers, the release rates were also determined in soil using a P visualization method, by comparing the P diffusion zone around a coated granule with that around uncoated granules. Similar release rates were found in water as in moist soil. The EC method hence offers an easy way to quickly evaluate the release of nutrients from slow-release fertilizers.

Utilising traditional and digital soil mapping techniques to facilitate research on a cattle station, Queensland

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The Spyglass Beef Research Facility (SBRF) spans 38,000ha of typical beef producing country in northern Queensland. SBRF was purchased for the conduct of world-class research, development and extension to advance tropical and subtropical beef production. An integral part in the facility's development is the generation of good quality soil and land resource information, including soil maps. A soil and land resource assessment was conducted on SBRF with data enabling researchers and station staff to optimise the building of critical infrastructure (fencing, laneways, water points, gates and paddock layout) and facilitate experimental design of research trials.

In order to provide a comprehensive set of data for the station, there were two components to this survey: a traditional mapping component and a digital soils mapping component. The traditional survey mapped soil types at 1:50,000 scale (appropriate for grazing activities) and produced a soils map for the entire property. This was supplemented by digital soil mapping (DSM) across the whole property. Maps of soil attributes relevant to grazing and animal research: soil depth, soil texture, pH/soil nutrients (e.g. available P, available K, available S, total N, organic C) were mapped across the property using DSM techniques (Regression Tree and Random Forest). These attributes were modelled on a 90 × 90m grid size at multiple depths across the entire property. It is intended that the digital soil mapping products can be used in pasture growth models for the station.

By utilising both techniques we can provide a comprehensive foundational data set for the property. It is intended that these maps and data, in conjunction with other datasets relevant to grazing, are used to support the research activities on SBRF into the future.

Increasing the capability of Agriculture Victoria staff in soil science knowledge, development and extension

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Integrated soils management extension leads to improved soil productivity. This has been observed in individuals who work in soil knowledge transfer and extension and have gained access to avenues that enable their capability development. The Victorian Government, in particular the then Farm Services branch, recognised that whilst knowledge existed within the team and their networks, there was a need to increase the capability, capacity and confidence of the collective extension staff to deliver integrated soil management extension to improve soil productivity. This led to the establishment of a new peer mentoring group called the 'Soil Champions'.

The Soil Champions consisted of thirteen extension staff, from all regions across the state, who worked together to improve their understanding of soil management to support modern, innovative production systems across all sectors. Soil management skills and knowledge developed and tested by the group is extended to farmers and industry service providers with a view to ensuring consistent, evidence-based strategies to combat constraints to production.

A key to this style of peer learning and capability development is the support that the group offered its members, where they can share the latest soil related products and services as well as teaming up with soil researchers to build capability to deliver improved services and soil science information to farming communities. The Soil Champions project has resulted in the development of a number of new partnerships across not only Agriculture Victoria and the greater Department of Economic Development, Jobs, Transport and Resources, but has improved collaboration with the private sector service providers and other government and non-governmental organisations.

Improvements in the transfer of knowledge of soil science for enhanced on-farm decision making requires a pathway to implementation, and the Soils Champion network has succeeded in achieving this outcome.

The effect of optimum vs. deficit irrigation on nitrate leaching from late spring deposited urine

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Urine patches are widely recognised as the primary source of nitrogen (N) loss from grazed pastures in New Zealand and present a significant environmental problem. Recent research has shown that the inclusion of plantain and chicory in the pasture mix (called "diverse pastures") can reduce the concentration and amount of N deposited in urine patches compared to standard perennial ryegrass and white clover pastures. However, few studies have compared diverse pastures and standard ryegrass and white clover pastures with respect to the effects of irrigation management on plant N uptake and nitrate (NO3-) leaching losses. The objective of this research was therefore to determine the effect of optimum vs. deficit irrigation management regimes on N uptake for diverse and standard pasture species and the subsequent effects of these irrigation regimes on annual NO3- leaching losses from soil.

An experiment, using soil monolith lysimeters (500mm diameter, 700mm deep), measured N leaching losses and plant N uptake following cow urine application at either 500 or 700kg N ha-1 in late spring. Following urine application, irrigation water was applied at optimum vs. deficit rates from November to March. Measurements were undertaken for a 10-month period following urine application.

The results from this study will increase our knowledge and understanding of irrigation management on grazed pastures and could be used to help determine best management practices to minimise NO3- leaching loss.

Can the degree of texture contrast predict hillslope soil erodibility?

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Determining the soil erodibility (or K-factor) for the Revised Universal Soil Loss Equation (RUSLE) has been problematic because various relevant soil parameters have variable importance in the entrainment and removal of soil particles by slope-wash processes.

We used an innovative approach based on bioturbation and geomorphic extension of soil formation factors (Paton et al, 1995) to hypothesise that the difference in soil texture between topsoil and subsoil is related to long-term soil erodibility. This is because, other factors being equal, sites with highly contrasting topsoil and subsoil textures would be expected to have had greater removal of fine-grained bioturbated surface materials by slope-wash processes than sites with less erodible soil materials.

To test this hypothesis we used the difference between digitally mapped and modelled D50 (the geomorphic mean of particle size diameter in mm) for 0–10cm and 30–100cm soil depths as a texture contrast parameter. Digital soil mapping for NSW is based on over 50,000 profile descriptions, including over 4000 profiles with particle size analysis of major horizons and related covariates. Using the Multi-Criteria Spatial Analysis Shell (MCAS-S) we spatially explored D50 and soil erodibility relationships across 16 million pixels for NSW. We examined the difference between topsoil and subsoil D50 against the RUSLE nomograph derived K factor derived from the same data set. We also spatially compared the difference between topsoil and subsoil D50 against the product of rainfall erosivity, long-term cover factor, slope and slope length for relatively undisturbed land uses such as forests, national parks and unused crown land, for groups of soils with the same parent material.

Preliminary results indicate an overall weak correlation with conventional USLE K factor. There are, however, also some highly variable and spatially interesting relationships between the degree of texture contrast and hillslope erosion factors.

Depth-specific scaling properties of soil water storage

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Knowledge of the spatial distribution of soil water over a range of spatial scales and time has important hydrologic applications. Data intensive measurements of surface soil water using remote sensing approaches have established that the spatial variability of soil water can be described using the principle of self-similarity (scaling properties) or fractal theory. This information can be used in determining land management practices provided the surface scaling properties are retained in the deep layers. The objectives of this study were to examine the scaling properties of subsurface layers and their relationship with surface layers at different initial soil water conditions over time. Soil water storage (SWS) down to 1.4m depth at seven equal intervals was measured along a transect of 576m for 5 years in Saskatchewan, Canada. The surface SWS showed multifractal nature only during the wet period (from snowmelt until early summer) indicating the need for multiple scaling indices in transferring soil water variability information over multiple scales. However, with increasing depth, the SWS became monofractal in nature indicating the need for a single scaling index to upscale/downscale soil water variability information. In contrast, all soil layers during the dry period (from early summer to the end of the growing season in the fall) were monofractal in nature, possibly resulting from the high evapotranspirative demand of the growing vegetation. This strong similarity between the scaling properties at the surface layer and deep layers provides the possibility of inferring soil water dynamics in the whole profile using the scaling properties of the easy-to-measure surface SWS data.

Teaching field research in soil science using the problem-based approach

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Professional opportunities in soil science demand successful applicants have experience using an integrative, cross-disciplinary, teamwork approach to problem solving. Currently there is a movement to promote engagement and teamwork, improve comprehension, and enhance critical thinking by implementing problem-based learning into the soil science curriculum. Our aim was to develop a field research course in soil science under this problem-based framework. The main concept was a central field research problem for students to develop, design, and work on throughout the term. Students were assigned into groups with a wide range of skills and backgrounds to simulate a professional working environment they will face in the real world. Students were asked to document their learning challenges faced with this new learning approach through multiple surveys, discussions, reflective commentaries and evaluations. Suitable assessments and timely feedback were crucial in ensuring the successful outcome from this style of teaching. Some challenges faced by students were quite similar to the challenges faced by working professionals in the field of soil science. These key challenges include effective time management, assignment of roles, and division of labour. Most students reported improvement in knowledge retention, verbal and written communication skills, ability to work in teams, critical thinking, and problem-solving skills. Problem-based learning is an effective teaching approach to prepare students for a career in the soil science field.

Mitigating ammonia losses from beef cattle feedlots with lignite

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Techniques combining open-path Fourier transform infrared spectroscopy (OP-FTIR) with an inverse dispersion model (backward Lagrangian stochastic technique, bLS) and quantum cascade laser (QCL) based eddy covariance were used to quantify CH_4, N_2O and NH_3 emissions from large cattle feedlots. The daily averaged NH_3 flux was 192g/head/d, nearly three times IPCC Tier II modelled estimates, accounting for about 70% of diet nitrogen. For an average size feedlot of 15,000 to 20,000 cattle in Australia, the daily NH_3 loss is equivalent to 6 tonnes of urea fertilisers. Application of lignite reduced NH_3 loss by 65%, which resulted in much higher (about 3 times) N content in manure when compared to the control. The application of N-rich manure to irrigated sorghum increased the biomass yield by 40%. The technique is economically viable.

Short-term effect of land use change on dissolved organic carbon dynamics in pastoral hill country

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Land use change from perennial pasture to forage cropping is rapidly being adopted in New Zealand hill country in order to increase animal feed production. Such changes in land use may have implications on the leaching and availability of dissolved organic carbon (DOC) in subsoils. DOC is a major factor limiting subsurface denitrification, therefore changes in DOC dynamics could impact on nitrate leaching to ground and/or surface waters. In this study, the effect of agrochemicals, particularly glyphosate (used for clearing out pasture before crop establishment) on DOC dynamics was studied to understand how these affect the net quantity and quality of DOC in the soil profile. The study was carried out on a Massey University hill country farm near Palmerston North. Two treatments were monitored – pasture and cropping. The cropped plots were sprayed out (one-off application) with glyphosate at 4L/ha before they were surface sown (no cultivation) to swedes (*Brassica napobrassica*). Soil samples were collected from various depth increments to a depth of 1m, prior to and after (Day 1, 6 and 12) herbicide application. The results showed that glyphosate (which contributed >50mg/kg to the total carbon content of the soil) significantly increased DOC in the surface 5cm of the soil on Day 1 and 6. A modelled daily water balance for the soil with a plant-available water of 22.5mm H20 per 100mm soil predicted a fairly static system with regard to solute transport – this supports why significant differences were recorded only in the top 5cm of the soil. Carbon aromaticity in DOC increased with soil depth, indicating the easily degradable nature of the agrochemicals. Seasonal monitoring of the treatments will enable definite conclusions to be drawn regarding the effect of crop establishment and soil moisture on DOC dynamics.

An APSIM model to describe the preferential transport of solutes in soils

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When rainfall or irrigation occur at high intensity, water may flow preferentially through cracks and large pores in the soil profile. In this situation, part of the soil is not involved in the transport of water or solutes and this momentarily increases the likelihood for leaching of surface-applied solutes. Evidence for preferential flow has been shown for various soils in different regions and it seems to be nearly ubiquitous. Despite being recognised as a common phenomenon, preferential flow is often not considered in modelling analyses; its natural variability and the complexity it would bring to the model seem to be the main reasons for this omission. The APSIM model framework is increasingly being used to study the fate of nutrients in soils from New Zealand and Australia, with a considerable amount of work done on describing the effects of urine patches on nitrogen leaching. However, the preferential transport of nitrogen has not yet been explicitly considered as this functionality is not present in APSIM. In this paper the implementation into APSIM of a relatively simple approach to account for preferential flow is presented and demonstrated. This model is largely based on the concepts introduced by Addiscott and Whitmore (1991) , but keeps interesting features of APSIM's SoilWater model. With this addition, APSIM can be used to help with the study of preferential flow, establishing the relative potential effects of this phenomenon, and with comparisons against results from recent lysimeter studies in irrigated Canterbury soils.

Long-term warming increases nitrogen availability but has reduced carbon mineralization in an alpine environment

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Climate warming is expected to impact on soil and plant processes in alpine ecosystems. Increased ambient and soil temperatures are likely to increase plant growth and organic matter mineralization. However, over time these effects are likely to change, due to changes in the C:N of soil organic matter, soil mineral-N availability, and in plant assemblages which in turn alter the type and quality of leaf litter. In addition, increased temperatures will affect the frequency of dry–wet cycles and drying depth. This study examined the effect of litter addition and dry–wet cycle on nutrient cycling of soils from long-term warming trials.

Incubation experiments used soils from plots of 10-year warming studies on the Bogong High Plains in south-east Australia. It was found that soils with a warming history had decreased microbial biomass and activity in addition to decreased N-mineralisation. However, there was increased C-mineralisation in warmed soils after they were amended with litters differing in the C:N ratio. Interestingly, warming history increased soil-available N and decreased soil respiration in response to dry–rewetting cycles. These effects were associated with the lower initial microbial biomass (MBC), reduced MBC and increased C use efficiency after dry–rewet cycles in comparison to non-warmed soils.

In summary, while increased temperatures would have been predicted to increase C and N mineralization, it is likely that over time, due to increased frequency of dry–rewet cycles, that soil-C is conserved due to a reduction in microbial activity.

Fert$mart planning for dairy farmers in Tasmania

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The Fert$mart programme has been developed by Dairy Australia to ensure dairy farmers are provided with appropriate knowledge and support to make good decisions about fertiliser application, thereby reducing nutrient runoff from their farms while still ensuring maximum pasture growth.

Fert$mart provides farmers and advisors with a planning approach and the know-how to produce more feed at no extra cost. Fert$mart plans are developed one-on-one with farmers, and the key messages are that fertiliser is expensive, don't waste it, and that using fertiliser is about the right product, right rate, right time and right place for maximum profitability.

Tasmania currently has three Fert$mart advisers with others seeking accreditation. Ninety Fert$mart plans have been delivered over the past 18 months. The Fert$mart plan involves a number of steps. These include collection of farm data so that farm production goals and feed requirements are known; access information for calculating the nutrient budget; a farm map; accessing previous soil tests; collection of soil samples; soil analysis; understanding the effluent disposal system and disposal areas; and assessment of pasture and soil condition, including soil structure and drainage.

Soil testing of more than 1200 paddocks found that only 3% of paddocks were in the optimum ranges for all soil fertility indicators of pH, P, K and S. This indicates that there is a huge opportunity to improve performance of Tasmanian dairy pastures by strategic application of lime and fertilisers to get more even fertility across farms. Soil testing is critical to targeting money spent on fertiliser, especially in tight seasons.

Farmers are doing several things differently because of their Fert$mart plan, including effluent going on different parts of the farm; more soil testing; changed fertiliser mix and application rates; targeting fertiliser to specific areas; and increased liming programmes.

Getting to the root of the problem: Soil, nitrogen, water and root dynamics

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Increasing drought and the cost/sustainability of nitrogen (N) fertiliser use are of growing concern. Overuse of N fertilisers has resulted in high environmental costs, such as leaching of soluble N forms and nitric oxide pollution into the atmosphere. Therefore, plant use efficiency of N is not maximised. This may be further exacerbated by drought conditions, because soil N availability is regulated by soil moisture. With climate change models projecting that water availability will become more erratic in the near future, the demand for understanding combined effects of variable water and N supply on wheat (above- and below-ground) is necessary.

Plants have evolved, or been bred for, root traits which optimize water and N uptake. Here results of an experiment in which root responses to combinations of water and N stress are presented. This work focused on identifying root traits associated with water and N uptake efficiency in plants, the hypothesis being that the suite of traits responsible for (efficient) water uptake would be the same for N uptake. The experiment was carried out at the Plant Accelerator® using the DroughtSpotter, which permits very fine-scale control of soil moisture dynamics by precisely measuring pot weight in real-time and irrigating plants according to a pre-programmed water level. The aim was to quantify the impact of different soil moisture regimes (adequate, deficit and variable) and increasing levels of soil N supply on soil N cycling, N uptake and root response in wheat.

Identifying and quantifying root responses of wheat to varying degrees of water and N stress will provide better insight into how crops and the environment interact. Understanding trade-offs between water and N uptake efficiency can lead to the development of crop management strategies to help improve crop productivity and improve the environmental and economic sustainability of food production.

Soil sensor data for profitable agriculture

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In collaboration with Southern Farming Systems (SFS), the Centre for eResearch and Digital Innovation at Federation University Australia has embarked on a research project that will enable farmers and their advisors to make more informed decisions based on easy access to around 60 soil moisture and temperature probes throughout southern Victoria and Tasmania.

Initially installed by SFS, the ongoing maintenance of the sensor network is funded by the host farmers (because they see individual value), so the data collection is self-sustaining. In agreement with the host farmers, some information from the probes is available to other users free of charge, hence the public can access the basic soil moisture information, including the percentage of soil moisture left in the profile (compared to field capacity) and information on soil moisture over the recent past. By comparison, the host farmer can log in to see extended sensor information, including the current temperatures and soil moisture readings down the profile, the weekly values, graphs of past values, field capacity and percentage of soil moisture left, water use for a period, and other information as determined by the collaborative research. The time series rainfall and temperature data from the co-located weather station or nearest Bureau of Meteorology weather station can also be shown. An easy-to-use tick-list allows the farmer to set alerts to any specified soil moisture and/or temperature condition, delivered via either SMS or email.

Soil management and productivity are the focus of the research, such as critical moisture contents to avoid pugging and machinery compaction, nitrogen application to avoid nitrous oxide losses when soils are wet and temperatures are rising, and moisture at various times of year to sow summer cover crops, or estimate yield potential to decide to cut for hay, harvest or graze.

Changes to soil organic carbon following soil modification: A South Australian perspective

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The addition of clay to sands has been widely undertaken in South Australia, with the first recorded clay spreading occurring in the 1970s. Clay addition has led to increases in agricultural production and changes to soil physical and chemical properties. Analysis of over 1100 soil characterisations in South Australia has shown a positive correlation between clay percentage and soil organic carbon (OC). The addition of clay should therefore increase the OC stock, but has this actually occurred? Analysis of OC concentration on over 100 previously clay modified sites compared to a small number of unmodified controls has delivered variable results, with OC stock increases between 0 and 22t ha-1 in the 0–30cm depth when compared to a suitable non-modified sand. The data does identify that OC concentrations are altered where the A1 and A2 horizons are mixed and the greatest increase in OC stocks occurred in the 10–30cm depth where clay has been incorporated into the bleached A2 horizon. The large variability in the results are hypothesized to be a result of a number of factors, including time since clay addition, amount of clay added, size of the clay clods, depth of incorporation, the nutrient status of the soil and the amount of organic material incorporated with the clay. It is not known if the modified soils have reached a new OC equilibrium or if they are requiring further time to reach maximum capacity. These results provide further understanding of the changes to OC over time and will assist in developing the most effective options for building OC in clay modified soils. Apart from the potential increases to agricultural production from increasing OC, developing the capacity to predict changes to OC following clay addition may also allow farmers entry into carbon trading markets.

Mineral formation in *Euglena* as a marker for biologically driven sediments

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Euglena mutablis is a photosynthetic protist often found in acidic aquatic environments, including geothermal lakes, peat bogs, and acid mine drainage systems. These environments are generally considered toxic to biota with *E. mutablis* considered a bioindicator of these landscapes. Capable of both photosynthetic metabolism and organic matter synthesis, it is highly likely that these protists not only cope with extreme environments, but may act to drive mineral formation and precipitation. Acid mine drainage (AMD) landscapes total to over 300 significant sites in Australia, at which *Euglena* spp. have been identified at over half. Formation of organo-mineral complex may accrue organic materials and meta-stable environments. This alteration to thermodynamics may explain several phenomena related to various mineral formations found in sediments in soils from acid mine drainage (AMD) systems.

In this work, *E. mutablis* from pure culture and sourced from AMD systems was cultured in synthetic AMD. The growth characteristics of the protists were studied in a range of typical AMD waters (pH 0.5 to pH 4.0) and precipitates collected and identified using scanning electron microscopy and powder x-ray diffraction. Confocal microscopy techniques were utilised to better understand the dynamics of mineral precipitation both internal and external of the protists.

Collected precipitates from the experiments were compared to sediments and soils that were collected in AMD systems. The *E. mutablis* precipitates were dominated by highly crystalline hydronium-jarosite with a decreased likelihood of potassium- and plumbo-jarosite (even when the experiment was tailored to preference these forms). The experimental results were reflected in the collected sediments but not in the collected soils, which were dominated by potassium-jarosite. Overall, this research demonstrates that standard thermodynamic models for mineral formation may not hold true when *E. mutablis* is present.

Storage and depth distribution of dissolved organic carbon under different land-uses of NSW Australia

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Carbon accumulation in surface soils is well documented but very little is known about the mechanisms and processes that result in carbon accumulation and long-term storage in the deeper soil profile. Understanding soil carbon storage and distribution mechanisms is critical to evaluate the sequestration potential of the soils of different land uses. Recent investigations have demonstrated that the movement of dissolved organic carbon (DOC) in the soil profile could contribute significantly to the carbon balance of terrestrial ecosystems. However, very little is known regarding the importance of DOC to vertical distribution of the soil organic carbon (SOC) pool through the soil profile in different land-use systems, management practices and conditions prevalent in Australia. We investigated the quantity and distribution of DOC through the profile under three different land-use systems in northern NSW, Australia. A series of site clusters containing a representative range of land-uses (woodland, pasture and cropland) were selected across the region. Within each land use, we determined total organic carbon (TOC) and DOC concentration and quantity down the soil profile to a depth of 0–100cm using six soil depth increments. Here we discuss the distribution of SOC and DOC down the soil profile and the relative importance of DOC to the storage and distribution of carbon to 1.0m depth. We compare and contrast the patterns associated with the different land use systems and explore potential mechanisms of carbon cycling in these soils. Our results provide new insights into the mechanisms and importance of DOC to the soil carbon cycle in Australian soils.

Supramolecular chemosensing materials as soil copper test kits

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Copper is a vital nutrient for plants; however, high concentrations may be detrimental to plant health causing a significant reduction in seed germination, growth, and in extreme cases, plant death. Copper may accumulate through addition of sewage sludge, pig manure, mine slag, or more commonly through copper containing fungicides and fertilisers. Therefore continual monitoring of copper concentrations may be vital to maintaining heathy soils in these environments. However, current analysis techniques are often out of reach of local landholders and members of the community, as they require expensive laboratory based instrumentation such as atomic absorption spectroscopy or inductively coupled plasma mass spectrometry. Hence the development of a portable inexpensive 'test kit' with a simple and fast procedure for soil testing is required.

Supramolecular chemosensors have shown potential as materials for highly selective recognition of metal ion and/or anion species through a visible and/or fluorescent colorimetric response. It has been the purpose of this work to develop a new chemosensor with a selective response to copper ions. Based off salicylaldehyde and naphthalene molecular units, this chemosensor expresses colorimetric detection for copper ions via a colourless to yellow colour shift in copper containing solutions. To detect exchangeable copper in soils, standard approaches using ammonium chloride (1:10 w/v 1M NH4Cl) or calcium chloride (1:10 w/v 0.1M CaCl) were used. Addition of a methanol solution containing the chemosensor to the supernatant produces a positive response for copper. When used in conjunction with ultraviolet–visible spectroscopy (UV-Vis) and Beer's Law, the detection for copper can be used for quantitative measurements.

The chemosensor presented in this research may be easily adapted as a cheap and effective field technique for qualitative (basic colour change) and quantitative (field portable UV-Vis) detection of copper in soils. Furthermore, these 'test kits' may empower local landholders and members of the community to undertake rapid assessments of metal ion detection in their own soils without the need of equipment-intensive methods.

Capability and suitability of soil in Laos

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In addition to improving our knowledge of how soil can sustain sustainable crop production for farmers in northern Lao PDR, there is also an opportunity to generate soil data that could be used to identify opportunities for crop diversification which may result in the incorporation of cash crops. This paper presents the development of soil property maps predicted on a 100m grid covering the most northern provinces of Lao PDR. The properties predicted can be used to answer the question "What can this soil do?", which describes the soil's capability. Soil maps describing physical and chemical properties have been generated along with maps of the prediction intervals, which are used to determine how reliable the prediction is at each point. This paper also highlights that soil properties that change over longer time scales (more than 100 years) are useful in this sort of mapping exercise, while properties that change rapidly (within a growing season) should be monitored locally. Using this, combined with properties that describe the soil's condition, the opportunity to infer soil suitability maps using criteria for a food crop and cash crop are also presented.

Selection of cattle supplement feeding areas to reduce nutrient and sediment loss in surface runoff

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Nutrient and sediment loss from hill country can impair water quality of receiving streams and rivers. This study quantified the surface nutrient and sediment runoff loss associated with feeding hay supplements to cattle in hill country on two contrasting soil types. The research was carried out at Massey University's hill country farm called Tuapaka, located near Palmerston North, NZ. Two sub-catchments (~0.3ha) were defined using 1m LiDAR digital elevation data and then instrumented to collect surface runoff. One sub-catchment was composed of a Korokoro soil, which is at higher risk of surface runoff due to its imperfect drainage and medium P sorption capacity. The second sub-catchment was made up of Ramiha soil, which has a low risk of surface runoff due to good drainage and higher P sorption capacity. Runoff samples were collected over a 43-day period during winter 2015. During this time, two herds of 16 mixed-age Angus cows were fed 2kg DM/cow/day of hay in a defined feeding area within each sub-catchment. There were 7 runoff events over the study period. There was 4.5 times the volume of surface runoff measured from the Korokoro soil compared to the Ramiha soil. As a result, the Korokoro soil lost 4.5, 7.3, 5.5 and 2.5 times the amount of total N, total P, dissolved reactive P and sediment, respectively, compared to the Ramiha soil. Surface losses of nitrate-N from the Ramiha soil were undetectable over the study period, but were <0.07kg/ha from the Korokoro soil. Whilst total nutrient losses were low over the short study period (<0.22kg total P/ha and <0.7kg total N/ha), the results highlight the benefits of strategically placing cattle feed supplements in winter on areas less prone to surface runoff. These findings are important as they present a simple, cost neutral method of reducing nutrient and sediment losses in sensitive agricultural environments.

Fate of soil N when long-term pasture soil was chemically fallowed for 13 years

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Long-term bare fallow experiments can provide valuable information on the dynamics of soil N in the absence of plants. In 2000, a 13-year field trial was established in Lincoln, Canterbury, NZ, that included a bare fallow treatment. Prior to the trial, the site, on a Wakanui silt loam, had been under sheep-grazed pasture for many years, so the soil was in good structural condition. The fallow plots (9 × 28m; three replicates) were kept plant-free using herbicides (not cultivated or fertilised during the trial). Plots were sampled regularly to determine the total stock of N (to 25cm depth) and N in labile organic matter fractions (particulate organic N and microbial biomass N). Each year, nitrate leaching was measured during winter (May–September) using suction cups placed at 60cm. The trial also included a control treatment where replicated plots represented the original grass-clover pasture. Pasture plots were grazed using sheep (typically 10 times per year; 20 sheep per plot). Both the pasture and fallow plots were irrigated during summer (leaching was not measured over summer). Under bare fallow, total N in the top 25cm decreased by an average of 112kg/ha each year (total N declined by ~20% during the trial). Relatively large losses of N occurred from the labile fractions; collectively, particulate organic matter and microbial biomass accounted for about half of the N that was lost. Total leaching loss of nitrate-N from the fallow plots during 13 successive winters was ~1000kgN/ha (annual leaching loss ranged from ~15 to 230kgN/ha, depending mainly on winter rainfall). In contrast to the large leaching losses of N from fallow plots, minimal leaching of N (total ~40kg/ha over 13 winters) occurred in the pasture plots. These results highlight the important role of plants in maintaining soil organic matter and in mitigating nitrate leaching losses from soil.

N mineralization potential of amending dehydrated urban food waste (UFW) on contrasting acid agricultural soils

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Land application of organic waste (OW) is an environmental and agricultural practice for enhancing soil organic matter, reclaiming degraded soils and supplying plant nutrients (Audette et al, 2016) and avoids potential environmental impacts associated with direct organic waste landfill or waste incineration.

Food waste is a big concern as it accounts for one third of municipal solid waste, and is poorly recycled or reused. Globally, around 1.3 billion tons of food is wasted each year, which contributes a direct economic loss of US$750 million and of AU$5.9 million. These organic food wastes also contain nitrogen (and phosphorus), thus increasing the agricultural value.

Nitrogen mineralisation from organic materials is a key process for understanding the N dynamics in ago-systems. There are many factors which could affect net N mineralisation and availability in soils and this is exacerbated with respect to food waste owing to the complexity of waste, current processing methods, and the interaction with different soils.

This work will focus on the N mineralization of dehydrated urban food waste (UFW) on contrasting soils. UFW is the output of dehydration, or quick composting technology, which is widely utilised in Melbourne, Australia, as a popular way of processing food waste. The aim of the work is to investigate N mineralization behaviour under laboratory conditions, by directly applying UFW to three agricultural soils. We recommend appropriate application rates of UFW to land for maximum nutrient availability and minimum environmental impact.

Long-term effects of harvest removals and fertiliser on soil nutrients and productivity in planted forests

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Planted forests in New Zealand receive either very little or no nutrient inputs from fertiliser application, largely relying on inherent fertility. Consequently, the long-term productivity of New Zealand's planted forests depends on the maintenance of soil fertility over successive crop harvests. Understanding the impact of harvesting on soil fertility can be challenging as gains in forest productivity through genetics and silvicultural management have the potential to mask any productivity losses that occur due to reductions in soil nutrient supply. This risk to long-term productivity is compounded by aspirations to double productivity on the same land area, placing increased demands on soil nutrient supply. To ensure forest harvest management practices will not lead to a decline in planted forests' productive capacity over successive rotations, two long-term trials have been sampled at end of rotation to determine the impact of harvest residue removal and fertiliser addition on nutrient supply and forest productivity. The results are nationally important and make a significant contribution towards the international understanding of long-term planted forest nutrient sustainability.

Potential for non-urea urine nitrogen compounds to mitigate ruminant urine-derived nitrous oxide emissions

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Previous studies have hypothesized that non-urea urine nitrogen (N) compounds (NUNCs) in ruminant urine could play a role in reducing nitrous oxide (N_2O) emissions from urine patches, either by reducing N-substrate availability for N_2O emitting processes, primarily nitrification, or inhibiting the nitrifying soil bacteria that control this process. Urea-N is readily transformed into inorganic-N substrates that are precursors to N_2O, but it is unknown whether NUNC-N is as freely available for use by soil microbes. We hypothesized that increased NUNC concentrations in cattle urine would not reduce urine patch N_2O emissions because NUNC-N would be easily degraded and used by soil microbes. To examine these effects, we applied a water control, synthetic urine control, and 5 synthetic urine treatments with elevated NUNC concentrations to perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) pasture. The NUNCs examined were allantoin, creatinine, creatine, uric acid, and hypoxanthine. Daily N_2O fluxes were determined for 35 days along with inorganic-N, surface pH, soil oxygen, temperature, and water content. Pasture cuts were taken on Days 16 and 35. Cumulative N_2O emissions increased in the urine treatments, but none of the NUNC treatments significantly varied from the urine control. There were no significant differences between treatments in inorganic-N concentrations, pH, or dry matter pasture yields. NUNC treatments had slightly, but not significantly, higher N_2O emissions in Days 15–35 compared to the urine control. Therefore, increasing the NUNC concentration did not reduce inorganic-N availability, and this was reflected in no change to cumulative N_2O emissions.

Change in soil organic carbon stocks under twelve climate change projections over NSW, Australia

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Digital soil mapping (DSM) techniques involving Cubist decision trees in combination with a space-for-time substitution (SFTS) process were used to map and examine changes in soil organic carbon (SOC) due to projected climate change over NSW until approximately 2070. Mapping was carried out over two broad depth intervals (0–30 and 30–100cm) at 100m resolution. Twelve climate change projections were applied, derived from four global climate models downscaled with three regional climate models.

Considerable variation in both direction and magnitude of SOC change was demonstrated with application of the different climate projections, with some models predicting an increase while others predicted a decrease. Statewide predictions for the upper depth interval ranged between 2.9t/ha gain and 8.7t/ha SOC loss. It is evident that greater consistency between climate change projections is required before we can confidently predict future changes of SOC and other soil properties.

Broad trends in SOC change were, however, revealed using averaged results from the twelve climate projections. A mean overall decline of 2.0t/ha SOC across NSW for the upper depth is predicted. Although changes are primarily controlled by the balance between changing temperatures and rainfall, the extent of change is also dependent on the precise environmental regime, with differing changes demonstrated over 36 current climate-parent material-land use combinations. For example, the projected mean decline of SOC over the upper depth is less than 1t/ha for dry-highly siliceous-cropping regimes but over 15t/ha for wet-mafic-native vegetation regimes. DSM-SFTS techniques offer a viable alternative approach to dynamic simulation techniques to predict and identify patterns in the change of soil properties due to climate change.

Factors controlling organic carbon stocks and their decline following clearing over eastern Australia

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Understanding the potential of soil to store organic carbon is important for potential climate change mitigation strategies and also for assessing soil health issues. We examined the factors controlling soil organic carbon (SOC) stocks and their decline following vegetation clearing in eastern Australia. Models were developed using a range of covariates to represent key soil forming factors together with multiple linear regression and Cubist piecewise decision tree models. Independent validation demonstrated concordance correlation coefficients up to 0.68 for SOC density in the upper intervals but progressively decreasing with depth.

The results demonstrate the necessity of considering a combination of factors, particularly climate, parent material/soil type and land use/groundcover, when deriving meaningful estimates of potential SOC stocks and their loss following clearing. Stocks in the 0–30cm depth interval were shown to systematically vary over 45 environmental regimes from 16.3t/ha in dry, highly siliceous parent material environments with low groundcover, up to 145.0t/ha in moist, mafic parent material environments with high groundcover. The proportion of SOC stock in the 30–100cm interval as a proportion of the top 100cm was shown to vary from a low of 41% in wet climates up to a high of 59% in dry climates. Climate appears to be the dominant controller of subsoil SOC storage proportion, with parent material/soil type and vegetation cover also having partial influence.

A total loss of approximately 0.53Gt SOC was calculated following vegetation clearing since European arrival over New South Wales. The greatest losses in both absolute and relative terms are demonstrated in moist climates with mafic parent materials (44.3t/ha or 50.0%), with only relatively minor losses associated with dry climates with siliceous parent materials (less than 1t/ha or 4%).

Topsoil fertility status of dairy farms in New Zealand, 2009–2015

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The fertility status of topsoils (0–7.5cm) from dairy farms in New Zealand was assessed during the period 2009–2015 with respect to Quick Test K (QTK), Olsen P, sulphate-S (SO4-S) and pH, focusing on the proportion of farms in the optimum soil test range. The soils were grouped according to soil types, namely: Sedimentary, Ash, Pumice and Peat. For each nutrient, the optimum soil test range percentages over the 7-year period fluctuated as follows: QTK [Sedimentary (31–33%); Ash (22–26%); Pumice (20–24%); Peat (19–25%)]; Olsen P [Sedimentary (38–42%); Ash (33–36%); Pumice (25–30%); Peat (23–33%)]; and SO4-S [all soil types had similar proportions (7–10%)]. For pH, the proportions in the optimal range were comparable in all the mineral soil types (25–32%) while it was much lower in the Peat soils (10–18%). Regardless of soil type, Olsen P had the highest percentage in the optimum soil test range (23–42%), followed by QTK (19–31%), then by SO4-S (7–10%). Thus, there is scope to optimise S levels in dairy soils through regular S fertiliser application. For pH, 25–32% of the farms within the inorganic soil types are in the optimal range while for Peat soils it was below 20%. The proportion of farms in the above-optimum range for Olsen P varied from 12–17% for all soil types except for Ash soils, which had 23%. The proportions of farms in the high range were significant for Ash and Pumice soils (25–34%), less for Peat soils (16–26%) and considerably lower for Sedimentary soils (12–16%). Except for Sedimentary soils, a reduction in the amount of P fertiliser is warranted for the other soil types given the negative environmental impacts associated with excessive P application.

Effects of degradation on meadow soil nutrient limiting factors and vegetation biomass of Wugong Mountain

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Wugong Mountain is located in the west of Jiangxi Province, China. In recent years, the scale of tourist activities, the number of tourists and the continuous extension of the scope has resulted in Wugong Mountain meadow community composition and productivity degradation to a great extent. This study focuses on Wugong Mountain's three different altitudes (1850m, 1750m, 1650m) in the area and distribution of degraded meadow in non-degraded meadow soil nutrient content and nutrient limiting factors and aboveground biomass were evaluated and analysed, in order to explore the relationship between soil nutrients and vegetation biomass, and provide a theoretical basis for nutrient management and the selection of grass species in the meadow restoration process. Results show:

1. The non-degraded meadow soil (CK) is acidic, and rich in organic matter content, except Mg, Fe, S elements, there is a lack of other nutrient elements in different degree; the degradation of soil organic matter content in meadow is relatively low, except Ca, other elements were lower than those of non-degenerate; with the altitude increasing, soil in N, P, K, Mg and Zn content increased.
2. Meadow degradation changed the adsorption of some nutrient elements in soil, the degradation in the three altitudinal range of meadow soil on K, P, B adsorption capacity was greater than CK soil.
3. Wugong Mountain meadow soil is a serious lack of P elements and Ca elements. The main nutrient limiting factors and the order of the deficit is: Ca>K>P (1850m, no degradation), B>P>Ca>N (1850m, degradation); Ca>P>N>K (1750m, not degraded), Ca>P>B>Zn>N (1750m, not degraded); Ca>P>K>Mo (1650m, not degraded), Ca>P>Zn (1650m, degradation).
4. The vegetation on the ground and underground biomass and soil pH was negatively related to density and the content of Ca, and a significant positive correlation with Zn content and N content.

Effectiveness of weed matting on riparian plant establishment

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River bank erosion has been identified as an issue for water quality resulting in recommendations for planting of the interface between aquatic and dryland ecosystems (the riparian zone). Riparian planting is associated with considerable costs in clearing, planting and ongoing management, particularly with respect to weeds.

A restoration project at Lake Ōkoroire in South Waikato presented the opportunity for measurement of plants 1 and 3 years old in comparison with plants 2 years old established under weed-matting. Bank 1 plants (now 3 years old) and Bank 3 (1 year old) were established using the Council-recommended method of glyphosate for weed control (recommended as 2 sprays pa for 5 years). In year two, weed matting was allowed by Council on Bank 2 (now 2 years old) before planting, eliminating the need for glyphosate. A retrospective comparison was made between groups. Plants with weed matting were vigorous, flowering, and supported considerable bee activity. Plants per m2 were 88% greater under weed mat than year 3 plantings. Estimated cover of desired species was double on the weed mat site (2 years old) compared with the 3-year-old site (45% and 18%). Weed suppression, including blackberry, was apparent, reducing the need for chemical control. Plant mortality on the 1-year-old site was 35% – a loss of $3,180 in plants alone. Average soil temperature was higher (0.2–0.3°C) under weed mat. No significant difference in soil moisture was found under different treatments.

Weed matting control was estimated to cost $8,742/ha, compared to initial glyphosate control costs of $15,100/ha per spraying (equivalent to $151,000/ha over five years). Replacement plant costs would be in addition.

Further research is required to assess the viability of different types of weed matting.

Proximal soil sensor surveys using gamma radiometrics assist delineation of precision management zones

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A gamma radiometric sensor has been used to survey two Hawke's Bay farm sites (33 and 102ha). The sensor detects gamma ray photons that are emitted naturally by the atomic nuclei of certain elements (potassium, thorium, uranium) in soil minerals as well as the integrated signal over the whole range of the sensor (total counts). The mobile radiation detection system (Radiation Solutions RS-700) continuously recorded georeferenced values, as the vehicle travelled at a speed of approximately 10kph, providing a dense point cloud for the survey areas. The raw data were pre-processed and converted into maps, using ordinary block kriging. Electrical conductivity (EC) and fine-scale pedological surveys were also conducted at both sites. At the first site, gamma radiometrics clearly distinguished a Brown soil from Recent soils; the Brown soil having lower total counts and the soil boundary between these two soil orders more clearly delineated than by the EC survey. The EC map was effective at differentiating soil texture and moisture differences in the Recent soils. At the second site, both gamma radiometrics and EC survey differentiated the patterns of Takapau, Rāwai, and Poporangi soils. The poorly drained Poporangi soils with pans are found in depressions and parts of the landscape where surface channels are common, and are delineated particularly well by the EC, gamma total counts and U maps, but less so by the K and Th maps. The maps derived from the gamma and EC surveys showed good agreement with the maps produced by pedological survey at these two sites, although sometimes grouping more than one soil type into one class. This numerical approach to mapping and classifying soil differences is being used to guide sampling and monitoring positions for precision management of productive land.

A comparison of soil map information for FDE management on two farms in Auckland region

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Managing the land application of farm dairy effluent (FDE) is an increasingly important issue for farmers as regional authorities develop policy for FDE management and the National Policy Statement for Freshwater Management is implemented. Correct FDE land application to minimise the risk of environmental effects often requires the farmer to follow specific policy conditions or guidelines, including the amount and rate of FDE application and storage requirements. Underpinning these conditions is the identification of effluent runoff risk by means of a developed FDE risk classification of soils (Houlbrooke et al, 2012). Current industry guidelines and regional authority policies commonly promote S-Map to identify high and low FDE risk soils for farm FDE management. This is likely because of S-Map's perceived national consistency, intended national coverage, inclusion of FDE classification in the factsheet, its increasing interoperability with OVERSEER®, and because costs are offset by regional and national funding. In contrast, alternative sources of soil information (New Zealand Land Resource Inventory (NZLRI), historical soil maps and farm-scale soil maps) either do not have FDE soil risk classification attached, or require interpretation or mapping by a soil scientist at a cost. This paper compares soil information from two farm-scale soil maps with available S-Map and NZLRI soil information to examine the influence of soil map scale on assessing FDE soil risk. For both farms, the total areas of high and low FDE soil risk differed depending on the source of soil map information. Finer resolution high and low FDE soil risk areas were identified by farm-scale soil mapping. The farm-scale soil map information provided a more accurate fit of the soils in the landscape. This allowed for more precise application of FDE to land according to soil risk and improved the accuracy of FDE storage calculations.

Houlbrooke D., D. Hicks, F. Curran-Cournane, M. Martindale, and V. Vujcich. 2012. Categorisation of soil risk associated with land application of farm dairy effluent: Auckland region. Auckland Council, Auckland.

Application of multiple wavelet coherence for revealing multivariate relationships between soil water and environmental factors

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Multiple wavelet coherence has been recently developed for examining scale-specific and localized multivariate relationships in geosciences. It has been shown that multiple wavelet coherence outperforms other common multivariate methods. Soil water content (SWC) is usually controlled by multiple environmental factors, and their controls may vary with scale and location. However, there is poor understanding on the multi-scale and multivariate controls of soil water in the landscape. The multiple wavelet coherence method was applied to examine multivariate controls of SWC at a scale-location domain in a hummocky landscape of North America. Bivariate wavelet coherence showed that depth to $CaCO_3$ layer and cos(aspect) were the best single factor for explaining SWC variations in the spring and summer, respectively. Multiple wavelet coherence showed that a combination of the best single factor (i.e. $CaCO_3$ layer in spring and cos(aspect) in summer) with soil organic carbon content resulted in the greatest fraction of area of significant coherence to the total scale-location domain. This indicates that these two factors are optimal for developing scale-specific prediction of SWC in the hummocky landscape. This method can be applied in water resources science, hydrology, and many other subject areas where a variable of interest is controlled by many factors at different scales and spatial/temporal locations.

Microbial communities responsible for dissimilatory nitrate reduction to ammonium (DNRA) in a rainforest soil

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Dissimilatory nitrate reduction to ammonium (DNRA) is the process by which nitrate and nitrite are reduced to ammonium by microorganisms. DNRA in soil is important because it allows nitrogen to be conserved as NH4+ in highly reducing conditions, in contrast to denitrification, where nitrogen is lost as N2O and N2. Although it has sometimes been assumed that DNRA does not play a significant role in soil nitrogen transformations, there is increasing evidence that DNRA is important in many soils, particularly forest soils under highly reducing conditions where there is a high C/NO3- ratio. In this study, soils from a rainforest gully in Victoria, Australia, were incubated at 60% and 100% water holding capacity. 15N labelling techniques were used to quantify gross N transformation rates and to evaluate the importance of DNRA for each treatment.

Residue retention and tillage effects on abundance of SOC fractions in low input continuous maize

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Smallholder farmers manage the largest proportion of arable land in Eastern and Southern Africa and their capacity to manage existing soil fertility resources are therefore of key importance to long-term regional food security. Minimum tillage and residue retention are the most widely adopted principles of conservation agriculture (CA) and are frequently promoted as suitable technologies for preventing further soil fertility decline. In this study we quantify the abundance of labile potassium permanganate oxidisable carbon (PPOC) and particulate organic carbon (POC), amongst other soil organic carbon (SOC) fractions, in the surface soil layers at two sites near Harare, Zimbabwe. Plots at each site were continuously treated with different levels of nitrogen (N), tillage and crop residues for 5 to 7 years. Contrary to previous studies, our findings show that N application rates (0 and 90kg N ha-1) did not influence labile and particulate organic carbon fractions. There was also no significant difference found in accumulation of total SOC between different residue loads of 4 and 8t ha-1, indicating that changes in SOC accumulation are not strongly linked to above-ground biomass inputs. Throughout Sub-Saharan Africa (SSA), soil fertility of CA cropping systems is often affected by a combination of multiple factors not commonly experienced in other published studies. In this SSA case study, previously intense tillage regimes, extremely high capacity for soil N leaching, temperature and moisture availability fuelling rapid decomposition, and prevalence of soil fauna (e.g. termites) and strong seasonal winds reducing duration of residues retained were all highly influential on the results of this study. We are currently analysing archived soil samples for changes in C and N pools during the cropping cycle with a view to elucidate N dynamics in low input CA systems.

Greenhouse gas emissions and microbial community structuring in NZ pasture soils

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It is well established that microbial communities contribute to ecosystem processes like N cycling. While regulators of communities and emissions have been independently established using a few sites, validation of these regulators by comprehensive studies across large geographic, climatic and edaphic ranges are lacking. Prior work using 13 NZ and Irish soils was able to link microbial community composition and N2O emission potential with pH and soil classification. Here we combined high-resolution denitrification kinetics and 16S rRNA gene amplicon sequencing in a study covering 50 pasture soils from across 11 of New Zealand's major soil groups, 10 geographical zones and under different grazing systems (high input dairy units to dry-stock grazing). Our results confirmed pH as a conserved regulator of both microbial community structuring and emission potential. However, community structuring based on soil classification was less clear within the 50 soils data set, whereas rainfall was identified as a potentially important driver of community composition. Further, we identify specific microbial populations associated with emissions, and partition the effect of other edaphic factors in predicting microbial community and emissions potential.

Design and specification of facsimile kandosols for the Barangaroo development

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The concept for redevelopment at the former international shipping terminal, now known as Barangaroo Point, was to re-establish a naturalistic Hawkesbury Sandstone headland with its associated endemic floral assemblage. The design team commissioned a soil scientist and horticulturist to design and specify the technological aspects, including the soil and vegetation edaphology.

The design constructed the core of the headland from fill from site then placed manufactured soil profiles appropriate to the vegetation over the resulting hillside terracing, waterfront promenade and plateau areas. Largely indigenous nursery-grown flora was then established.

Soil design started with a conceptual soil profile composed of crushed sandstone, washed quartz sand and composted green waste, mimicking the natural Yellow Kandosol that supports sandstone flora. Benchmark analysis against the very low fertility levels found in intact Yellow Kandosols (around 30mg/kg total P) allowed pot trials to be performed testing the suitability of the soils for endemic species. Five edaphic vegetation zones were decided upon, requiring four soil materials, a subsoil, a topsoil for turf and park trees, a topsoil for dry woodland soils and a topsoil for heath components. The designs used the "ashbed" concept to elevate nutrient levels as they are after a bushfire (around 70–90mg/kg total P) to allow the vegetation to develop properly but draw down nutrient levels to those found in the benchmark analysis of natural soils over time.

The trialled designs were then written into tender specifications. Strict quality control of manufactured soil was implemented to ensure soils met the requirements of this sensitive vegetation assemblage. While soil design for the project was occurring, trials in the production nurseries were conducted to develop an improved nutritional programme and new growing media for large plant specimens to avoid transplant interface effects.

The major driving force of the food and energy production and consumption in Australia's nitrogen footprint

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The nitrogen (N) footprint is a novel metric that was developed to estimate reactive N (Nr; all species of N except N2) released to the environment by human activities. It provides a new perspective for N use efficiency and connects lifestyle choices (e.g. food and energy consumption) with N losses. Australia has a unique situation for Nr management given its abundant natural source and low population density. Here we report, for the first time, that Australia's N footprint (47kg N cap-1 yr-1) is the largest (both in food and energy sectors) among all countries for which the N footprint has been estimated using the N-Calculator model. About 69% (32kg N cap-1 yr-1) of Australia's N footprint is attributed to food production and consumption, with the rest from energy consumption (15kg N cap-1 yr-1). The high food N footprint is mainly due to beef consumption and production, while the heavy dependence on coal for electricity explains the large energy N footprint compared to other countries. Better N management strategies and lifestyle choices that can reduce the N footprint are needed for addressing the challenges of food security and environmental conservation in Australia.

Nitrification is a primary driver of nitrous oxide production in an agricultural soil

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In recent years, identification of the microbial sources responsible for soil N2O production has substantially advanced with the development of isotope enrichment techniques, selective inhibitors, and the discoveries of specific N-cycling functional genes. However, little information is available to effectively quantify the N2O sources (e.g. nitrification and denitrification), and the underlying microbial mechanism of N2O production is unclear as well. Here, a 15N-tracing incubation experiment was conducted under controlled laboratory conditions [50%, 70% and 85% water-filled pore space (WFPS) at 25°C and 35°C] to determine nitrification-sourced N2O and denitrification-sourced N2O. 10 atom% 15NH4Cl and K15NO3 were applied to distinguish N2O production pathways, and QPCR was used to quantify the functional gene amoA to explore the relationship between N2O emission and ammonia-oxidizing archaea (AOA) and ammonia-oxidizing bacteria (AOB) abundance. The soil was used in the study with 0.52% total N, 5.2% organic C, 19% clay, 38% silt and 43% sand. The soil pH (H2O) was 4.5 and NH4+-N and NO3--N were 13 and 93mg kg-1 soil, respectively. At 50%, 70% and 85% WFPS, nitrification contributed 87%, 80% and 53% of total N2O production, respectively, at 25°C, and 86%, 74% and 33% at 35°C. The percentage of nitrified N as N2O (PN2O) increased with temperature and moisture, except for 85% WFPS, when PN2O was lower at 35°C than at 25°C. AOA were the dominant ammonia oxidizers, but both AOA and AOB were related to N2O emitted from nitrification. AOA and AOB abundance was significantly influenced by soil moisture, more so than temperature, and decreased with increasing moisture content. These findings can be used to develop better models which may be added microbial variables for simulating N2O emission to inform soil management practices for improving N use efficiency.

Effects of *Phyllostachys edulis* expansion into adjacent forest on soil nutrient concentrations in subtropical China

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Moso bamboo (*Phyllostachys edulis*) is a typical native invasive species for the neighbouring tree in Asia. However, the expansion of moso bamboo into the adjacent native forests has potential to induce alterations of soil chemical characteristics due to the high growth rate of this plant. We select three contrasting forest types – *Cryptomeria fortunei* pure forest (CF), *Cryptomeria fortunei* forest invaded by moso bamboo (PH-CF), and moso bamboo pure forest (PH) – to evaluate the effects of moso bamboo expansion on the temporal changes of soil carbon (C), nitrogen (N) and phosphorus (P) in the Lushan Mountain, subtropical China.

Results showed that forest types significantly affected the soil C, N and P pools in our study. The soil C content in PH-CF forest was 55.56g kg-1, which was significantly higher than that in PH and CF pure forests by 23.6% and 53.4%, respectively. The soil N concentration in PH-CF was 2.42g kg-1, which was also significantly higher than that in PH and CF pure forests by 34.4% and 149.5%, respectively, suggesting that the expansion of moso bamboo into CF forest would enhance the soil C and N storage due to the higher growth rate of moso bamboo. On the contrary, the soil P content in PH-CF was 0.21g kg-1, which was lower than the other two forests, indicating that the fast expansion of moso bamboo significantly reduces the soil total P contents.

In conclusion, our results show that the expansion of moso bamboo into adjacent forest may greatly threaten the growth of *Cryptomeria fortunei* by reducing the soil P concentration. Therefore, further studies are very necessary to investigate the underlying mechanism of soil nutrient alterations within moso bamboo expansion for the healthy and sustainable development of neighbouring native forests in the Lushan Mountain, subtropical China.

Sludge compost as a fertiliser for crop growth

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The agricultural land application of biosolids (treated sewage sludge) is the predominant end-use of biosolids produced from metropolitan wastewater treatment plants in Western Australia. The use of biosolids is regulated by the Western Australian guidelines for biosolids management to ensure minimal risk to human health and the environment. Biosolids supply essential plant nutrients; loading rates are typically based on providing adequate nitrogen for crop growth. Nutrient availability in sludge-compost, produced by combining partially treated sewage sludge from regional wastewater treatment plants with straw and animal manures, is less understood. The nutrient content of sludge-compost is less than for biosolids, and therefore may require higher loading rates and/or the addition of inorganic fertiliser to optimise plant growth. This study measured the addition of four rates of sludge-compost (equivalent to 0, 4, 8, 12 dry t/ha) and an inorganic basal fertiliser treatment on vegetative wheat growth and nutrient uptake. The experiment was conducted in the glasshouse in pots containing 3.5kg of sand in a randomised block design and replicated thrice. The addition of increasing rates of sludge-compost improved vegetative growth of wheat compared to the nil control over 7 weeks' duration. The dry matter of wheat shoots at 53 days from sowing in sludge-compost applied at 4, 8, 12 dry t/ha measured 12.1, 15.8 and 18.2g/pot, respectively, compared with 8.2g/pot in the nil sludge compost treatment. Wheat growth was highest in the inorganic fertiliser treatment (23.5g/pot) indicating that the rate of sludge-compost was too low and/or additional nutrients were required to maximise plant growth. Nutrient analysis of dry matter of wheat shoots at harvest are being analysed to determine critical nutrient levels for the sludge-compost rates used. The findings will enable recommendations concerning sludge-compost loading rates to be made to further test under field conditions.

Catch crops reduce the risk of nitrogen leaching after winter grazing

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Nitrogen (N) leaching losses require careful consideration because of the related risks to surface and ground water quality. In New Zealand, the greatest risk period is typically during the months of winter and early spring when drainage events are more common. This period coincides with the grazing of high yielding winter forage crops (e.g. kale, fodder beet), an important management strategy to maintain livestock productivity during winter when pasture growth is constrained. However, the high stocking densities that are often associated with winter forages mean that these production systems are particularly susceptible to high N leaching losses from animal urine-deposition areas that typically remain in a fallow state for 3–5 months after grazing. This long fallow period provides a window of opportunity for establishing winter-active catch crops to 'mop-up' residual soil mineral N. This two-year field study investigated the potential benefit of establishing either an oat [*Avena sativa*; Years 1 (2015) and 2 (2016)] or ryecorn (*Secale cereale* L.; Year 2) catch crop in a winter forage crop system under high N loading conditions (400kg N/ha as urea), simulating urine deposition areas. The catch crops were direct-drilled on two sowing dates (early July and early August, both years), and changes in soil mineral N (0–120cm depth) and biomass production were assessed. In Year 1, oats reduced soil mineral N throughout the profile between the months of September to November (final harvest). For example, under simulated urine, soil mineral N was reduced by approximately 33% by early September at 0–120cm depth, and 71–75% by late November at 90–120cm depth, compared to the respective fallow treatments. Oat yields at final harvest were similar for both sowing dates at 10–12t DM/ha, removing approximately 230–240kg N/ha from the soil. Results of the trial in Year 2 will also be presented with comparisons made between the oat and ryecorn crops.

Impact of manure-based biochars on ammonia volatilization from soil

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Ammonia (NH3) volatilization is one of the most important sources of nitrogen (N) loss in soil-plant systems worldwide. It is estimated that between 10 and 30% of N fertilizers may be lost through NH3 volatilization after application. In recent years, carbon-based materials such as biochar have created research interest because of its ability to increase soil fertility and reduce pollutants. Studies have also identified that the addition of biochar can reduce NH3 volatilization in soil. Laboratory-based incubation experiments were carried out using urea as an N source (at a rate of 300kg ha-1) to investigate the influence of feedstock (poultry manure, green waste compost and wheat straw), pyrolysis temperature (250, 350, 450, 500 and 700˚C), and application rates (1 and 2%) on NH3 volatilization in different soils with pH ranging from 6.0 to 8.5. An acid trap (sulphuric acid, 0.5M H2SO4) was used to capture NH3 gas. The captured NH3 was determined by back titrating the unconsumed H2SO4 with 0.1M sodium hydroxide (NaOH). The experiments were carried out for 30 days in a temperature controlled room at 24˚C. The study identified that biochar properties, pyrolysis temperature and application rates played an important role in reducing NH3 volatilization. For instance, the addition of PM-BC 350 (2%, pH 7.39), GW-BC 450 (2%, pH 8.03) and WS-BC 450 (2%, pH 8.01) to soils reduced NH3 volatilization by 53.03%, 37.89% and 34.93%, respectively. In contrast, the addition of PM-BC 350 (1%, pH 7.90), GW-BC 450 (1%, pH 8.03) and WS-BC 450 (1%, pH 8.13) to soils reduced NH3 loss by only 37.73%, 25.66% and 7.98% respectively. Reduction of NH3 volatilization through the application of biochar is either due to changes in pH or through NH3 sorption. Soil pH is reduced after biochar addition and due to the presence of carboxylic and phenolic functional groups biochar can reduce loss by trapping NH3 on its surface. This study underpins the enormous potentiality of biochar from manures and highlights the importance of pyrolysis temperature and feedstock in terms of decreasing NH3 volatilization from soils.

Greenhouse gas emissions from soil in mango and banana fields: Fertiliser and ground cover management

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Nitrous oxide (N_2O) emissions from agricultural soil are contributing to global climate change. The emissions originate from microbial nitrification and denitrification processes, which are driven by complex relationships among soil water filled pore space, temperature, available nitrogen (N) and organic carbon. Banana and mangoes are tropical Australia's largest horticultural industries, with a combined value of >$6,000 million/year and area of 23,000ha. These industries primarily use conventional forms of N fertiliser (urea) in warm and wet conditions, a combination with the potential to produce high N_2O emissions. We investigated N_2O emissions from soils with conventional and alternative management practices in mango (chromosol) and banana (ferrosol) fields. Conventional management practice was the application of urea to bare soil at application rates of the local industry. Alternative management practices included a reduced application rate, the application of N fertiliser treated with the nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP) and ground cover treatments. The ground cover treatments compared the dominant current practice (bare soil) with added mulch in mangoes or living ground cover in bananas.

N rate had the greatest impact on N_2O emissions, with the highest N rates producing the greatest N_2O emissions. Peak N_2O rates were greater from bare soils in bananas (390µg N m^{-2} hr^{-1}) than mangoes (109µg N m^{-2} hr^{-1}), which is likely a result of soil type and temperature differences. Peak rates typically occurred with first rainfall (5–50mm) within a week of N application. Treatment differences then quickly diminished in the following days. DMPP did not lower emissions in comparison to the equivalent rate of urea when applied to bare soils on both trials. However, emissions from DMPP treatments in combination with mulch reduced N_2O emissions from mango soils. Samples from the living ground cover in bananas are currently being analysed.

Green solution to clean up pollutants: A scope for sustainability and soil productivity

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Land treatment of wastewater is providing economic and environmental benefits to both wastewater treatment industries and the farming community. Australian abattoirs discharge 7225ML of wastewater annually to the environment with high concentrations of nitrogen (N – 250mg/L) and phosphorus (P – 150mg/L), thereby causing environmental degradation. These surplus nutrients can be effectively recaptured by growing energy crops, eventually leading to cleaner energy production. In this study, a calcareous soil was irrigated with abattoir wastewater and four plant species were grown. *Pennisetum purpureum* (125g) and *Helianthus annuus* (115g) showed high biomass yields, followed by *Sinapis alba* (70g) and *Medicago sativa* (25g). The plants grown under tap water showed about 30% lower yields compared to the abattoir wastewater irrigation. A significant variation in root structure has been observed in between treatments and within the species used. In particular, the root length and number of root tips showed marked differences between wastewater and tap water treatment. The root length of *Pennisetum purpureum* grown in wastewater was 267cm $plant^{-1}$, which was comparatively lower than tap water irrigated plants (376cm $plant^{-1}$). Wastewater irrigation to the plants grown on calcareous soil improved the fertility of soil by adding essential plant nutrients, and hence the root structure was not diversified as seen in tap water irrigation. This can be attributed to the readily available nature of the nutrients from the wastewater compared to tap water, where there is a limitation in nutrient supply. The biomass produced can be used as a fodder and/or for energy production. A mass balance calculation on the overall nutrients over a few cropping periods will help us in understanding the nutrient cycling processes involved in the abattoir irrigated land treatment sites, which will serve as an effective tool for environmental management.

Influence of abattoir wastewater irrigation on plant growth and dry matter yield of selected plant species under field conditions

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A field experiment was conducted to study the effects of two wastewater types and loading rates on plant dry matter yield. In this experiment, seven crops (sunflower (Helianthus annuus), sugar beet (Beta vulgaris), canola (Brassica napus L.), alfalfa (Medicago sativa), maize (Zea mays), napier grass (Pennisetum purpureum) and giant reed (Arundo donax) were used with two loading rates (400mm yr-1 ha-1; 800mm yr-1 ha-1) with three replications. All the plots were harvested at the same time. Overall, the plots irrigated with 800mm wastewater (abattoir wastewater-AWW and Municipal wastewater-MWW) showed significantly higher yield than the plots irrigated with 800mm tap water (TW) in all the plots of seven plant species used. The overall trend in biomass yield for three water types and loading rates followed AWW 800mm > AWW 400mm > MWW 800mm > MWW 400mm > and TW 800mm treatment, for all the crops. In comparison with TW irrigation (800mm), AWW (800mm) showed a 270% higher DM yield (total biomass yield). Similarly, a significant increase in biomass yield was found for the two loading rates of MWW 400mm (26.7%) and 800mm (39.5%) compared to TW treatment in sunflower plots. The overall biomass data for the sunflower suggests that the trend in yield is as follows: AWW 800mm > AWW 400mm > MWW 800mm > MWW 400mm > TW 800mm treatment. The percentage increase in DM yield for sugar beet showed a 74.3% higher biomass yield in AWW (800mm) and MWW showed a 41% more biomass compared to TW. In canola, compared to TW irrigation (800mm), AWW (800mm) showed an 82% higher DM yield, which was highest among the seven crops used. Improved management can reduce the incidence of nutrient loss from wastewater-irrigated soils by calculating input and output ratio to avoid nutrient loss and seepage. Growing plants at the land treatment site with nutrient-rich wastewater can be a sustainable and economic method for disposal and management of wastes.

Soil type influences on root development of *Populus* × *euramericana* planted as poles

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There is little information on how soil type influences the development of coarse structural roots (i.e. those >1mm) in soil conservation trees established from poles (unrooted cuttings). This project aimed to determine the influence of soil type on the growth attributes of *Populus* × *euramericana*, a hybrid poplar, commonly used to provide soil reinforcement and protection against the initiation of shallow landslides on pastoral hill country in New Zealand. At three sites (Otoi, Pahiatua, Bideford), each located on a different geology where the soil type was either allophanic, sandy loam, or a clay loam, 25 3-metre long poles were established on sloping pastoral hill country. At each site, trees were selected for excavation and their above- and below-ground attributes measured annually 1, 2 and 3 years after planting. Lateral and vertical root distribution, root length and mass was recorded for roots >1mm diameter. Total root length (roots >1mm) ranged from 3m to 19m after one year, and from 12 to 87m after two years. Total root mass ranged from 8g to 58g after one year, and from 28g to 699g after two years. Root metrics were overall greatest in allophanic soil, with root development in clay loam slightly in advance of that in sandy loam.
Correlation will be sought between these findings and pole mortality as experienced in Regional Council funded plantings across soil types.

Aged biochar affects gross nitrogen mineralisation and nitrogen recovery: A 15N study in two soils

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Biochar is pyrolysed biomass, and when applied to soils, it could increase agricultural productivity through increased nutrient retention. The biochar-mediated nutrient retention capacity depends on the biochar properties, which change with time. Here, we examined the effects of a field aged biochar (21 months), applied at 20t ha-1 in two soil types, on gross nitrogen (N) mineralisation (GNM) and 15N recovery in a grassland field experiment using a 15N tracer. The experiment also included a phosphorus (P) addition treatment (1kg ha-1). We only found a significant increase in GNM in the sandy Tenosol, when it received both biochar and P. Biochar and P addition possibly enhanced microbial activity resulting in an increased GNM in the nutrient limited Tenosol. Biochar addition negated GNM in the clayey Dermosol, possibly due to stabilization of soil organic matter (SOM). Biochar significantly increased total 15N recovery in the Tenosol (on average by 12%) and reduced leaching to sub-surface soil layers (on average by 52%). Overall 15N recovery was greater in the Dermosol, but was not affected by biochar or P treatment. The increased N retention with biochar addition in the sandy Tenosol may be due to NH4+-N retention at exchange sites on aged biochar in the soil. Our results suggest that aged biochar may increase N use efficiency through reduced leaching or gaseous losses in sandy soils.

Effect of clay and biochar on the forms of phosphorus in the sandy soil

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In developing sustainable phosphorus (P) management strategies, it is crucial to understand P transformation among different fractions and pools. Here we report that application of clay, biochar and combination of clay and biochar may promote soil quality, therefore plants may use P efficiently. This study investigates the forms and distribution of phosphorus (P) after 1, 7, and 15 days in a Badgingarra soil that contained 98% sand, 0.6% silt and only 1.4% clay using a sequential procedure. Wheat straw (WS) and chicken manure (CM) biochar was added at rates of 0, 10, and 25t ha ^{1}. Clay also was added at rates of 0%, 3%, and 10%. A modified Hedley fractionation measured the amount and relative solubility of P after 1, 7, and 15 days of incubation. Results from this research showed that the stable fractions (organic P and HCl-P) mineralised to more available P as form of labile-P with the time. Net organic P present as residual-P increased with almost all amendments. Both biochars increased residual-P by 12–17% at higher rate (25t ha ^{1}) respectively compared to the soil without biochar added. Combination of clay and biochar also increased residual-P in the soil with time by 24–88% in comparison with the control soil and clay-only soil (P 0.05). Results from this research showed that P added by biochar and a combination of biochar and clay was preferentially found in the inorganic P (Pi), mostly in labile pools after 1, 7, and 15 days. The largest difference among the amendments was in clay plus biochar, which was significantly increased during incubation (32–63%).This paper now explores the assumption that the high levels of less soluble forms of phosphorus with clay and biochar at a higher rate, 10t ha ^{1}–25t ha ^{1} respectively, would, over time, become more available P.

Effects of aged biochar and repeated biochar application on soil microbial diversity

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There is a knowledge gap on the effects of aged biochar and repeated biochar application on soil microbial diversity. The aim of this study was to determine the effects of long-term and repeated biochar application on microbial diversities in a pasture soil. The treatments included B9 – aged biochar at the rate of 10t ha-1, applied 9 years prior to sample collection; B1 – newly applied biochar at the rate of 10t ha-1 applied 1 year prior to sample collection; B9+1 – repeated biochar application at the rate of 10 (9 years old) +10t ha-1 (1 year old) mixed one year prior to sample collection when aged biochar was in the soil for eight years; and B0 – control. The soil samples were collected in October 2015. Next Generation Sequencing of bacterial 16S rRNA genes targeting V1-V3 and V3-V4 regions using Illumina MiSeq platform was undertaken to investigate soil microbial diversity. The B1 and B9+1 significantly changed the soil bacterial community structure compared to B9 and B0. Significant responses in the relative abundance of phyla were detected for most of phyla in the B1 compared to the other treatments. Soil microbial community composition was well explained by soil pH, electrical conductance (EC), water soluble organic carbon (C), water soluble total nitrogen (N) and microbial biomass N (MBN).

Temperature effects on CO2 emissions and nitrogen transformations impacted by soil mixing with termite nests

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Global warming and nitrogen (N) deposition are important factors impacting soil carbon (C) and N cycling. Termites are important ecosystem engineers dominating the arthropod communities and also strongly affect C and N cycling, especially those building nests in woods, which may interact with warming and N impacting soil C and N cycling. Due to divergent C and N properties between termite nests and adjacent soils, when both soils mixed under natural conditions, non-additive effects magnifying or reducing their impacts on soil element cycles may occur. We collected termite nests or trails built in woods (termite nests) and control soils in forests at Jiangxi Lushan Mountain to understand the effects of warming and N deposition on C and N processes by termite soils. We measured total CO2/N2O emissions and N transformations (N mineralization and nitrification) when substrates were incubated in different temperatures (15°C, 25°C, 35°C) and N treatments (control vs. 4g N m-2). Termite nests had higher dissolved organic C and CO2 emissions. CO2 emissions decreased with N addition and increased with warming. N2O emissions increased with N deposition and increased with warming, especially in termite soils and mixed soils. Temperature increased net N mineralization rates but increases were smaller and more gradual in control and mixed soils than in termite soils. Mixing termite nests and control soils had synergistic (N transformations: +0.02~0.80mg kg-1 day-1; N2O emissions without N addition: +0.02ng g-1 h-1) and antagonistic (CO2 emissions: 0.16µg g-1 h-1; N2O emissions with N addition: -0.04ng g-1 h-1) mixing effects, indicating termite impacts on soil C and N cycling might be under- and over-estimated, respectively, based on each soil alone. In light of the remarkable abundance of termites, the effects of mixing termite nests and the control soils on soil C and N cycling should be considered under the context of global change.

Characteristics and spatial distribution pattern of plant community of mountain meadow in Wugong Mountain

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The flora characteristics of vascular plants and distribution types of Wugong Mountain mountain meadow, plant community diversity, the spatial distribution pattern of small communities were analysed, and the effect of human disturbance, for the rational development and utilization of Wugong Mountain mountain meadow vegetation protection, and to provide scientific reference for the recovery. The results show:

1. There are many types of Wugong Mountain meadow, investigation of ferns, gymnosperms and angiosperms belonging to 44 families, 90 genera, 108 species.
2. There are 12 families belonging to the type of distribution in the world, accounting for 27%, and belongs to the temperate tropical nature of the subjects were 13 families, accounting for 30%; 18 genera belong to the type of distribution in the world, accounting for 20%; 24 genera are tropical nature, accounted for 27%; 49 genera are temperate, accounted for 54%.
3. The *Miscanthus sinensis* is the dominant species of the whole plant community, followed by *Arundinella anomala* Steud. as the subdominant species, accompanying species such as *Hypericum ascyron* L. Selaginella and so on.
4. *Miscanthus sinensis* as the primary community, its distribution area is larger. There are 23 kinds of small communities in there. The horizontal distribution pattern, in the sunny slope and shady slope respectively have 11, 12 small communities, each community dominant species and edificators are not the same, and they are alone in the surrounding community. In the vertical distribution pattern, the altitude of 1900 metres only found a small community. With the increase of elevation gradient, changes in diversity index showed a wavy change. Analyse trends of beta diversity the 5 index, with the increase of elevation, 5 index fluctuation is larger, indicating the adjacent elevation between the species replacement rate varies greatly, lead to changes of beta diversity among communities.

Climate change impact on crop productivity: Legacy effect through plant–soil feedback

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Plant–soil feedbacks play a central role in nutrient cycling. Changes in crop productivity, resource allocation and nutrient uptake can impact soil nutrient availability in both the short and long term through changes in organic matter input into the soil. Projected changes in atmospheric concentrations of CO2 and temperature have been shown to impact crop productivity. However, the short-term nature of most studies makes it difficult to assess the full extent of altered climate on crop productivity through plant–soil feedback, thus potentially limiting our ability to predict the long-term implications of these changes. Here, we examined the main and interactive effects of elevated CO2 (CE) and temperature (TE) on cotton productivity in a controlled environment over two seasons to assess whether crop response was affected by the legacy of these treatments through plant–soil feedback, or remained consistent. A positive effect of TE on cotton yield was consistent between both seasons. However, we found a large difference in yield response to CE at ambient temperature (TA) between the seasons, with a significant yield reduction in the second season. Crop and soil nutrient analyses revealed reductions in leaf nitrogen contents and soil nitrogen availability under CETA, while belowground carbon allocation (e.g. root biomass, root and soil C contents), soil respiration and microbial biomass were significantly increased by CE, suggesting that the reduction in soil N availability may be caused by increased microbial immobilisation of soil nitrogen. These results indicate that the positive effect of CE on crop productivity may be dampened by negative plant–soil feedbacks that reduce nitrogen availability in the long term. Further research is needed to identify the underlying mechanism that drives such feedback effects to develop effective adaptation strategies to ensure sustainable agricultural production in future climates.

Nutrient regulations and soils data

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Rural landowners in five lake catchments near Rotorua have been regulated since 2005 by 'Rule 11', which imposes a cap based on their 2001–2004 nitrogen leaching and phosphorus runoff losses. In February 2016 new rules were proposed for the Lake Rotorua catchment to help meet the lake's sustainable annual nitrogen load of 435 tonnes. This target is defined in the regional policy statement and seeks to protect lake water quality in the long term. The proposed rules require progressive reductions in nitrogen losses to meet farm-specific nitrogen discharge allowances by 2032. The proposed reductions average 35% for dairy farms and 17% for dry-stock farms, relative to Rule 11 nitrogen leaching levels.

Lake Rotorua catchment nitrogen losses, as in some other regions of New Zealand, are assessed using the OVERSEER® nutrient budget model (OVERSEER). Within OVERSEER, the amounts of drainage and nitrogen loss are influenced by soil physical parameters entered by the model user. Recent upgrades to OVERSEER have simplified the uploading of S-map data, including soil drainage parameters such as profile-available water. This is part of the continuous improvement of OVERSEER through the incorporation of new science and integration with existing databases like S-map. However, there is a tension between this type of improvement and the certainty desired by both regulators and the regulated in the context of managing farm nutrient losses. The consistent quantification of nitrogen losses is also critical to nitrogen trading between farmers and/or sales to the public fund established to buy nitrogen in perpetuity.

This paper considers the differences in OVERSEER farm nitrogen loss estimates arising from using 'better' soils data. Methods to manage these differences are discussed, including the role of OVERSEER data input protocols and the interaction between nutrient policy and soil science.

Modelling increased Irrigation Efficiency and Reduced Leaching with Variable Rate Irrigation in combination with S-Map Data

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Declining water supplies make efficient use of irrigation water a major priority in agricultural production. To address this, the use of Variable Rate Irrigation (VRI) compared to Uniform Rate Irrigation (URI) enables a centre pivot irrigation system to optimise irrigation application by controlling the rate and location of irrigation depending on the available water of each Soil Management Zone (SMZ).

The spatial delineation of the SMZs, (soils with similar hydrological behaviour), was determined using electromagnetic induction survey (EC), supported by ground truthing and lab analyses. For each SMZ the soil water retention characteristic and saturated hydraulic conductivity were measured from samples taken from the first two top horizons. The measured data was linked to the national soil survey database (S-map) by finding the best relationship between the soil water retention characteristics of the measured data and the soil water characteristics of the possible range of S-map soil siblings mapped within each SMZ. For each SMZ the physically based agricultural systems model APSIM, was then run with long term climate data to estimate irrigation, drainage, runoff and crop yield. The analysis undertaken compared irrigation requirements under a URI scenario where irrigation water was applied to avoid moisture stress in the most drought prone soil zone, to a VRI scenario which matched the needs of each SMZ.

Land use at the case study site is mixed cropping and the results suggest that using VRI instead of URI can save up to 16 mm ha-1 y-1 of irrigated water and reduce 15 mm ha-1 y-1 of drainage which will decrease nitrate leaching. The advantages of VRI increase for deeper rooting crops and as the difference in SMZ water holding capacity increases.

This study also demonstrated how the S-map database can be used to supplement limited measurements of soil hydraulic properties so that a scenario simulation exercise can be undertaken to assess the potential benefits of VRI on a case by case basis.

A saturated hydraulic conductivity model for New Zealand soils using a bimodal characteristic curve and functional horizons

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Descriptions of soil hydraulic properties, such as water retention characteristics [θ(h)] and saturated hydraulic conductivities are a prerequisite for hydrological models. Since the measurement of the saturated hydraulic conductivity Ks is difficult, it is frequently derived from pedotransfer functions. Ks is typically more difficult to characterise than θ(h).

Recently, Pollacco et al. (2013) developed a physical model to compute Ks solely from hydraulic parameters derived from the Kosugi θ(h). This model, which is based on the pore size distribution and the arrangement of the pores of a soil, was developed by combining the Hagen-Poiseuille and Darcy equations, using three tortuosity parameters. We report here on further adaptations to this model to adapt it to dual-porosity structural soils, by computing the soil water flux through a continuous function of an improved dual pore-size distribution by Liu et al. (2013).

The improved Ks model was tested with a New-Zealand dataset derived from historical measurements of Ks and pore size distribution for a range of soils derived from sandstone and siltstone. The Ks data was collected using a small core size of 100 mm, causing large uncertainty in replicate measurements. We therefore developed an algorithm based on known relationship to remove outliers and thus significantly reduce the uncertainty of the measurements. Predictions of Ks from the new bimodal Ks model were further improved by distinguishing topsoils from subsoil. Nevertheless, as expected stratifying the data with functional horizons (two textures, two structure sizes and three soil strengths classes) only slightly improved the predictions of the Ks models since it is based on pore size distribution, and the calibrated parameters were obtained within the physical feasible range.

The improvements made by using the new bimodal Ks model are modest when compared to the unimodal model. Nevertheless, the new bimodal model provides an acceptable fit to the observed data. The study highlights the importance of improving Ks measurements with larger cores and more accurate measurements of total porosity.

Helping soils to breathe more easily – impacts on CH4 exchange

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Global climate change is now generally recognised as a phenomenon that has arisen due to increasing anthropogenic concentrations of greenhouse gases including methane (CH_4). As a large amount of New Zealand's exports are generated from land-based industries, emissions urgently need to be reduced. Methane oxidation is one part of the CH_4 cycle which has the potential to be employed for its capacity to naturally remove CH_4 from soil systems. Methane oxidising bacteria in 'natural' soils are sensitive to disturbance (physical and chemical), yet seem to be persistent regardless of soil management practices – CH_4 oxidation rates have shown signs of recovery as early as 10 years later in regenerating ecosystems.

Maintenance of soil structure is a good management practice, but soil physical properties can get compromised with the presence of animals and vehicles/equipment. This in turn can impact soil CH_4 exchange and productivity. Lessons can also be learned from how undisturbed systems operate in terms of maximising soil CH_4 uptake. This paper will provide an understanding of how predominantly soil physical conditions can be used to promote better soil health and hence encourage greater CH_4 removal rates by CH_4 oxidisers in the soil.

Reducing the loss of fertiliser phosphorus on soil types prone to leaching

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Phosphorus (P) in fertiliser applied to sandy soils is prone to leaching and hence warrants careful management. Eutrophication has occurred where excess P has entered waterways; for example, the Swan Coastal Plain in south-western Australia. Superphosphate fertiliser is responsible for much P used for agriculture; P leached into river systems in this region are estimated at 26 tonne P per annum. Modification of the chemistry of superphosphate, characterised by a high percentage of water-soluble P (86%) to create fertiliser containing a lower percentage of water-soluble P (35%) was tested in two experiments to quantify P leaching in an aim to reduce P loss. The first experiment comprised six fertiliser P treatments: superphosphate, low water-soluble superphosphate, three standard forms of phosphate and a control to leaching columns containing perlite. Over 4 weeks following a total of 900mm simulated rainfall, cumulative recovery of total P in leachate in low water-soluble P was 40% compared to superphosphate at comparable rates of total P. The second experiment tested the leaching of P following the addition of superphosphate, low water-soluble superphosphate and a control to three different soil types differing in P buffering index (PBI) (low, medium and high) following 900mm simulated rainfall. The concentration of P in leachate decreased for both fertiliser treatments as the PBI of the soil increased, as would be expected. Total P recovered in leachate in the low water-soluble superphosphate treatment was less compared to the superphosphate treatment on the low PBI soil (64% and 111%, respectively) and medium PBI soil (5.4% and 37.5%, respectively). The concentration of P in leachate in the high PBI soil for both fertiliser treatments was low. Low water-soluble superphosphate reduced P leaching compared with traditional superphosphate fertiliser on soils at risk of leaching.

Long-term effects of land use on soil organic matter fractions and carbon mineralisation

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Organic matter fractionation can provide deeper insights into the dynamics of soil C (and N) than is possible based on measurements of the total stock of organic matter. In this study we examined how organic matter associated with different particle-size fractions responds to changes in land use. The soils were from the ley–arable trials at Rothamsted, which were initiated in 1949. One trial site (Highfield) had been under grass for centuries and some plots were converted to arable cropping while others had been continuously fallowed since 1949. The second site (Fosters) had been under long-term arable cropping and, on this site, some plots were converted to permanent grassland while others remained under arable cropping. In 2012, samples were collected (0–10 and 10–23cm) from both trials. Archived samples (0–23cm depth) that have been collected at intervals over the course of the trials were also included in the fractionation study.

Sixty years after conversion from permanent grass at the Highfield site, C mineralisation in the top 10cm (measured in a 14-week laboratory incubation at 25°C) had declined by 67% under arable cropping and by ~90% under bare fallow. Carbon was lost from all of the measured fractions. Clay-associated C, the most stable C fraction, declined by 52% under arable cropping and by 70% under fallow (0–10cm). Largest decreases were in the particulate organic matter (POM; >50µm fraction); POM-C in the fallow treatment was only ~10% of that in soil under permanent grass.

At the Fosters site, C in all fractions was substantially increased by conversion from arable cropping to permanent grass. However, even after 60 years, stable C had not increased to the level found in the Highfield long-term grass treatment, confirming that C stabilisation can be slow, even under grassland where C inputs are large.

Soil hydraulic properties spatial datasets of Victoria

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Water retention and hydraulic conductivity are important soil hydraulic properties that govern the functioning of soil in ecosystems and are affected by soil management. Knowledge of the hydraulic characteristics of soils is essential for many plant and soil water studies including plant growth, plant water stress, solute movement, deep drainage and irrigation scheduling. The Victorian Government continues to invest in modelling activities that require robust soil hydraulic properties to test, understand and design future farming systems for Victoria. However, limited hydraulic data exists to support the current range of farming system models, such as Agricultural Production Systems sIMulato (APSIM), Catchment Analysis Tool (CAT), Soil & Water Assessment Tool (SWAT) and Soil Water Atmosphere Plant (SWAP). Therefore, the objective of this study is to provide soil hydrological spatial datasets for selected agricultural regions of Victoria in an accessible format for easy integration into spatial software and predictive biophysical models. The interim data set provided here includes measured soil hydrological properties and derived hydrological parameters for A and B horizons of dairy pasture soils. The dryland dairy pasture soils are from Gippsland and South West Victoria regions. A total of 30 dairy paddocks were sampled representing these two regions and three to four dairy grazing management practices. This data set contains soil hydrological properties and parameters on a total of 552 A-horizon and 552 B-horizon samples. Soil hydrological properties and parameters provided include solum depth, thickness of A and B horizons, bulk density, saturated hydraulic conductivity, field capacity, permanent wilting point, volumetric soil water content at nine matric potentials, soil porosity and soil water retention parameters (e.g. van Genuchten parameters). In addition, this data set provides some basic soil properties, including particle size distribution and chemical properties including organic carbon content. Soil hydraulic properties varied with soil types, soil texture classes and soil depths. For example, organic carbon content, bulk density and soil water content at field capacity and permanent wilting point ranged from 0.23–15.9%, 0.52–1.85Mg m-3, 0.087–0.627m3 m-3, and 0.015–0.450m3 m-3 respectively. Van Genuchten soil water retention function parameters wcr (residual water content), wcs (saturated water content) alpha and n ranged from 0.074–0.227m3 m-3, 0.422–0.708m3 m-3, 0.024–2.79cm-1, and 1.11–2.86 respectively.

Optimising fertiliser formulations for cereal biofortification with selenium

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Humans have been consuming inadequate levels of the essential micronutrient selenium (Se) for several decades, which puts them at risk of health problems. A cost-effective method of improving dietary Se is through the fortification of staple crops with Se fertilisers. Several studies have investigated the effect of applying different forms of Se (selenite and selenate) using a range of delivery methods (e.g. granular and foliar) to determine the optimal strategy for improving the Se status of crop plants. However, few studies have focused on the possibility of using existing fertilisers enriched with Se, which would inherently reduce labour and operational costs. We studied the effect of enriching common nutrient NPK and S fertilisers with Se on crop uptake. Fertilizer applications included urea (50mg N kg-1), muriate of potash (40mg K kg-1), mono-ammonium phosphate, di-ammonium phosphate and single superphosphate (20mg P kg-1) and sulfate of ammonia (20mg S kg-1). Sodium selenate was mixed with the above fertilisers, to obtain a rate equivalent to 10g Se ha-1 (3.33µg kg-1) and the resulting compound fertilizer mixture was pressed into tablets for soil application. The Se uptake from these fertilizers was compared in a pot trial with wheat, ensuring optimal nutrient supply in all treatments. Because Se dynamics vary significantly with soil conditions, two contrasting soils were used. A separate treatment looking at the effect of applying foliar Se-enriched urea on Se crop uptake was included, to compare the efficiency of contrasting Se application methods. Liquid urea mixed with sodium selenate solution (10g Se ha-1) was applied to wheat at ear emergence using a nebulizer. Selenium uptake data will be presented and differences in Se accumulation due to macronutrient carrier and application method will be discussed.

Monitoring land use change with landscape function analysis

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Landscape Function Analysis (LFA) is a monitoring tool that can be used to rapidly obtain the functional status of a soil landscape. The method was originally conceived to be used for monitoring the effects of stress and disturbance on landscapes and particularly following the rehabilitation of semi-arid landscapes or minesite rehabilitation. More recently LFA has been used in more temperate regions under a range of land uses.

LFA is underpinned by a conceptual framework, uses a comprehensive field methodology and provides an interpretational framework. The conceptual framework is based on the trigger–transfer–reserve–pulse (TTRP) model, which refers to landscape characteristics and processes that influence the distribution and retention of resources within a landscape. The field methodology involves the establishment of transects and recording site description. It relies on prescribed landscape organization parameters and the recording of 11 soil surface assessment (SSA) indicators. SSA scores are entered into a spreadsheet that provides results for three landscape function indices based on soil functions of soil surface stability, infiltration capacity and nutrient cycling potential.

Two case studies have been used to show that LFA can be used to effectively monitor and explain changes to soil functionality following land use change activities. The first examines restoration of degraded scaled soil in the semi-arid rangelands of NSW. The second involves examination of soil functionality following afforestation of grazing pastures in the temperate region of NSW. The results of these studies show that restoration leads to improvement in the stability, infiltration and nutrient cycling processes.

Reference

Tongway D.J., and N.L. Hindley. 2005. Landscape Function Analysis: Procedures for monitoring and assessing landscapes with special reference to minesites and rangelands. CSIRO Sustainable Ecosystems, Canberra, Australia.

Coating contact angle as a predictor of fertilizer stability in highly humid conditions

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Critical relative humidity (CRH) is the relative humidity at which a fertilizer begins to absorb moisture from the atmosphere. A relatively high CRH is advantageous for a fertilizer, because products with low CRH may become wet in storage or transport resulting in bridging and caking when exposed and handled under highly humid conditions. One way to increase the CRH of a fertilizer is to apply a hydrophobic coating which will resist water ingress. There are a large range of hydrophobic coatings which may meet this criterion. Screening coatings for efficacy in raising the CRH involves spraying coatings evenly over the fertilizer surface, which sometimes requires heating, followed by replicated moisture uptake measurements at five relative humidities between 50% and 80%RH in constant humidity chambers. Instead of this elaborate method, a fast, accurate screening method for coatings would be useful. Here we present a rapid technique based on measurement of water droplet contact angles on microscope slides, and their use to quantify the degree of hydrophobicity of a range of water-repellent coatings, and hence their potential utility in raising the CRH of fertilizer granules. This angle is measured between the edge of a water droplet in contact with the surface of interest. A high angle indicates a low degree of wetting of the coating, representing a high degree of hydrophobicity. A diverse range of coatings, including biopolymers, waxes, fats and resins, produced angles ranging between 20° and 114°. The CRH of fertilizers coated with these materials will be compared to CRH measurements on the same products to determine if contact angle measurements serve as a useful screening method to select coatings that increase CRH and reduce fertilizer caking.

Heavy metal contamination of Australian urban/peri-urban market garden soils

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If we demand our produce be locally sourced, how can we be sure it is free from pollution? Urban gardens and peri-urban landscapes have long supplied produce to local communities, but are the soils impacted by urban activities?

This research looks at the heavy metal concentrations across market garden areas in the greater urban NSW area. Whilst traditional agriculture has links with soil chemistry, smaller farms often do not see the benefit in the larger range of soil testing. Furthermore, very little is being put into rapid assessment of pollutants to aid land users to build upon traditional soil knowledge with rapid pollutant assessment. Soil quality has often been coined "poor man's chemistry"; however, as our landscapes become increasingly urban and peri-urban, our understanding of soil quality needs to also evolve to include assessments of pollutant load and mobility. This research used absolute sampling techniques to provide rapid elemental breakdowns of the soils, which can guide local farmers in their crop choices. Furthermore, through the mapping of these contaminant loads of varying soils in areas, this can be used to forecast problem areas, guiding future land use strategies for more sustainable undertakings. This will result in a better understanding of our impact on the environment.

We hope to be able to provide other disciplines with information on how these environments are responding to increased pollutant loads so that land management strategies could be evolved. This research will be able to guide us down a path of sustainability by providing us with information, from which we can track the effects we are having on soils and thus the environment.

Characterisation of high temperature biochar from green waste woody biomass

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The production of biochar and its storage in soils has been suggested as a means of abating climate change, by sequestering carbon. Substantial uncertainties exist surrounding the application of biochar to mitigate carbon emissions. This research explores the characteristics of multiple forms of biochar produced from green waste biomass.

In this work the physical and chemical characteristics of both biochar and initial biomass were investigated following a range of treatment protocols. Previous studies suggest that high temperature pyrolysis degrades much of the plant structure in biochar. Following protocols in this work, SEM investigation has shown that the pyrolysis conditions retained the structure of the initial biomass. NMR and Raman data shows that the amorphous structure of biomass has been converted into turbostratic crystalline structures, which have been previously used as a proxy for soil stability. SIMS demonstrated that levels of heavy metal are well within safe levels for application to soils, which will have no deleterious effects on fertility. NMR has shown that there is a slight peak that correlates to possible polycyclic aromatic hydrocarbons, which will need to be investigated further. Through the characterization of green waste we hope to tailor pyrolysis conditions, thus engineering a homogenous product whose characteristics would be suitable to a wider range of soils.

This research demonstrates that the management of the pyrolysis conditions has relevant impacts onto the structure and chemical composition of the final char; this has a flow-on effect, particularly on soil hydrological properties and processes. Analysis showed that high temperature pyrolysis ameliorates the apparent differences between biomass, providing a stable and homogenous product.

Detection of pharmaceuticals in soils

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This research explores the detection of pharmaceuticals in soils that are exposed to wastewater irrigation. Treated wastewater may contain a variety of emerging environmental contaminants including pharmaceuticals (antibiotics, prescription) and illicit drugs. Currently, many wastewater treatment plants are not required to remove pharmaceuticals, allowing for export of parent compounds and/or metabolites into the natural environment. There is increasing concern that the continuous discharge of these compounds may negatively impact the surrounding environment, decrease biological diversity in soils and waters, and increase the occurrence of bacterial antibiotic resistance.

In this work, soils from a productive agricultural area with an extensive history (over 50 years) of being irrigated with tertiary treated sewage effluent from municipal waste have been sampled and tested for the presence of a variety of pharmaceuticals using high performance liquid chromatography (HPLC) and nuclear magnetic resonance (NMR) techniques on waters and soil extracts. Scanning electron microscopy (SEM) and x-ray diffraction (XRD) were used to perform analysis on solid-phases.

The results indicate that traces of pharmaceuticals persist in the natural environment over extended periods of time. These potential environmental contaminants absorb and adsorb to soil particles. The consistent application of tertiary-treated wastewater results in a build-up of antibiotic resistant bacteria in soil, contaminating the soil.

The characterisation of farmed organic soils in the Waikato Basin

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The Waikato has about half of New Zealand's organic soils (formed in peat), about 80% of which have been drained and developed. The objective of this study was to characterise farmed organic soils in the Waikato region to help understand the range of soil properties.

Soils from six dairy farms between Rukuhia and Orini were described and samples were collected at depths of 0–7.5cm, 7.5–15cm, and 15–30cm. Anion storage capacity (ASC), organic matter content (OM%) and pH were measured. Two sites were identified as highly developed, two sites were identified as less developed and two sites had properties of both highly developed and less developed peat (mid-developed soil).

The results showed key differences between the highly developed and less developed organic soils. The highly developed soils had ASCs from 75–95%, OM% ranging from 29–48%, peat depths of 0.6–1.8m and humified organic matter composed of mainly sapric material. The less developed soils had ASCs ranging from 10–20%, OM% ranging from 70–82%, and peat depths ranging from ~4m to >10m. The less developed soil had a greater content of fibric material, especially at depths >30cm. The mid developed soils had medium to high ASCs from 51–71% coupled with high OM% ranging from 62–85%, and humic to mesic organic matter. Soil pH ranged from 4.42 to 6.28, but had no correlation to the stage of development. The differences between highly developed peats and less developed peats could be key factors in the pasture response to nutrient inputs and the fate of nutrients in the soil.

Long-term implications of soil fertility for soil biology in hill country pastures

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Long-term fertiliser and grazing trials yield valuable information. In this study we take a closer look at how the soil biology has changed on the long-term phosphorus fertiliser and sheep grazing study at AgResearch, Ballantrae. We sampled three farmlets: no fertility (NF), which received 156kg/ha/y of single superphosphate (SSP) from 1975–1979 and none since then; low fertility (LF), which received 125kg SSP/ha/y since 1980; and high fertility (HF), which received 375kg SSP/ha/y since 1980.
Earthworm abundance was first measured in 1979 (Lambert, 1986). While there was no difference in earthworm abundance between the LF (526m-2) and HF (644m-2) farmlets, there was a strong relationship between their abundance and pasture production. Since 1979 Olsen P values have decreased under NF, remained similar under LF, and increased under HF (Mackay and Costall, 201 6). A survey in the spring of 2014 across the same farmlets found earthworm abundance similar under LF (440m-2) and HF (440m-2), and double that under NF (220m-2). HF and LF had more epigeic *Lumbricus rubellus* and endogeic *Aporrectodea caliginosa* and fewer native earthworms than NF.
The heterogenetic hill country landscape also is a major determinant of the abundance and composition of the earthworm community. Greatest earthworm abundances were found on low (430–680m-2) compared with steeper slopes (110–240m-2). Medium slopes contained 80% of low slope populations under HF, but only 40% under NF. The influence of aspect has changed since 1979, with southwest slopes no longer having the lowest earthworm populations. We will discuss factors influencing the abundance and diversity of earthworms under different long-term soil fertility in a hill country landscape, including the changes in forage supply, and investigate the implications for soil services and the value of these services. We will also touch on the influence of changes in soil fertility on the wider soil biological community including mites, springtails and nematodes.

Can the impairment of root growth by soil acidity be overcome by biochar amendment?

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Acid soils can inhibit the growth of plant roots both directly, by the effect of soil acidity itself, and indirectly, through the solubilisation of toxic aluminium (Al). Here we investigated whether root growth inhibition could be ameliorated by amending soil with biochar and, if so, through what mechanisms. The biochars were made from either pine or willow woodchips pyrolysed at 550°C. The biochars were added to two acid soils (Typic Dystrochrept and Alic Hapludand) at application rates based on the pH-buffering capacities of both biochars and soils. Their effect was evaluated through (i) a radicle elongation bioassay using alfalfa (*Medicago sativa* L.) and (ii) a thorough chemical characterisation of the amended soils. The NaOH and Ca(OH)2 were used to help understand the mechanisms. Biochar addition increased soil pH and decreased labile monomeric Al in all treatments, but only willow biochar stimulated alfalfa seedling growth. Willow biochar was found to be a suitable liming amendment for the Inceptisol under study, as 1% of willow biochar enhanced radicle elongation. However, unrealistic application rates (ca 5%) of the same biochar were needed by the Alic Hapludand, which had abundant organo-Al complexes. An unbalance in the molar ratios of Ca/Na and Ca/∑(dominant cations) in soil solution when adding pine biochar was the plausible cause of the stunted radicle growth observed with this amendment. The addition of pine biochar to the Alic Hapludand also increased aqueous colloidal Al in solution, which is consistent with an enrichment of Na over Ca in solution. We conclude that when selecting a specific biochar to ameliorate acid soils, not only the liming equivalence needs to be considered but also the balance of Na to Ca (and Mg) for adequate plant uptake and soil structure.

Differences in quality of soil from Jarrah forest and a farmed land assessed

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In this 3rd year group project, a number of strategies were used to determine the quality of soils under virgin Jarrah forest (32°20'05.5"S 116°04'51.3"E) and a banana plantation at the University of Western Australia (UWA) (31°59'05.3"S 115°49'08.6"E). Soils collected from these sites were analysed for their chemical, physical and biological properties. A wheat crop was also grown with different nitrogen and phosphorus rates to assess productivity of these soils. Chemical analyses indicated that soils collected from farmed land had higher levels of plant-available N, P, and K compared to Jarrah forest soil. In contrast, Jarrah forest soil had higher organic carbon content and lower pH compared to the farmed land. The soil microbial status assessed through the 16S rRNA method showed higher abundance of microbes in farmed soil. The better quality of farmed soil compared with Jarrah forest soil as shown by the chemical and biological tests was also confirmed by better growth of wheat crop (3rd leaf extension rate, root and shoot biomass) in a glasshouse experiment. The result of this experiment showed that wheat grown in banana soil performed better than those grown in Jarrah forest soil. A significant difference in both the shoot (15.8g/pot) and root (110g/pot) biomass were observed in N100 with P0 treatment between the banana plot and Jarrah forest soil. In Jarrah forest soil, the application of nitrogen at 100kg/ha and 0kg/ha of phosphorus had gradually reduced the biomass of both shoots (4.44g/pot) and roots (5.94g/pot).

Analytical techniques and standardised procedures for biochar characterisation

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Biochar has remained a major research focus for scientists around the world in the last decade. Biochar production for soil application has been proposed for long-term carbon storage, energy production, waste management, improving soil properties for crop production and remediation and restoration of degraded soils. Whilst significant research efforts have been directed towards understanding the persistence of biochar in soils and its effect on soil properties and processes, the characterisation of biochar has been often done using inconsistent and sometimes unsuitable laboratory procedures. This has resulted in inconsistent and sometimes erroneous data reported for biochar properties, which make it difficult to compare the results of different studies and draw meaningful conclusions. An international workshop was organised to address this problem in December 2014. We gathered 21 biochars produced from different feedstock and using different temperatures. These biochars were analysed using a range of analytical techniques at specialised laboratories around the world, which has resulted into a collection of refined procedures and associated data for a range of biochars. Some examples of the uniqueness of data obtained from different techniques for biochars will be presented at the conference.

We have now compiled a book encompassing different analytical techniques and data obtained for a variety of biochars. Each technique chapter provides information on the technique's principle, unique information or data obtained from it, any drawbacks or pitfalls, and its complementarity to other techniques that are used for biochar characterisation. The first of its kind, this book has the potential to serve as a primary source on the analytical methods for biochar characterisation.

Towards two-dimensional infiltration measurement in complex and variable soil environments

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Monitoring how the infiltration rate changes over time gives insight into how the physical characteristics, such as soil structure, changes. Quantifying this change is useful when assessing how mine site rehabilitation soils settle in the years following the burial of mining waste rock. The actual technique for measuring the infiltration rate is currently done as a point measurement, which is statistically unreliable for an average reading when the environment has a high level of variability within its physical characteristics. It is proposed that Electrical Resistivity Tomography (ERT) has the capability to quantify the infiltration variability that exists in complex soil environments which contain features including mining waste rock, textural variations, and structural anomalies such as varying degrees of compaction. This research investigates the use that a time-lapsed measurement of soil moisture change over a two-dimensional transect has when attempting to track a wetting front through a soil profile. The project is broken into two stages, developing a methodology for tracking a wetting front, and applying the method to a variable soil to assess the accuracy. The first stage involves creating software protocols and inversion corrections that allow measurements of soil moisture to be corrected for time due to the ERT measuring in a successive technique with a specific order. As these corrections are developed, the soil moisture across a two-dimensional transect can be measured repeatedly at a known time interval, allowing the quantification of the soil moisture rate of change, or the infiltration rate at every point along that transect. Once this method is developed, it is replicated on a variable soil, which contains a large buried rock, a textural change and a compacted region. It is predicted that the minimum, maximum and average infiltration rates can be quantified, along with a statistical distribution.

The soil microbial biomass: A paradigm shift in terrestrial biogeochemistry

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Fifty years ago David Jenkinson introduced a new concept in soil science that placed the soil microbial biomass at the centre of terrestrial ecosystem functioning. In tracing the soil microbial biomass from its conceptual development to the latest understanding of its central role in ecosystem functioning, an ambitious new book provides pointers to future research as we seek to feed a burgeoning human community in a warming world.

The book begins at the beginning, with two of David Jenkinson's protégés telling the story of the soil microbial biomass, from the concept to the methods they developed for its measurement. This is followed by a discourse on its role in cycling nutrients, and how this now helps the sustainable management of organic matter in agroecosystems, including in paddy soils. One area where experiment exceeds existing theory is in explaining the huge biodiversity of the soil. In this chapter, the need is identified for new theoretical models to explain the causes and consequences of soil biodiversity on the structure and function of terrestrial ecosystems, and their responses to global change. The mystery of the soil microbial world is beginning to be revealed, with two chapters describing new tools such as dynamic stable isotope probing of the biomass, and molecular methods that together can help link the soil's rich functional diversity to distinct traits of different subgroups and their ecology. The development of new, microbially explicit models is being helped by these new tools, which another chapter shows are taking us beyond the simpler but still useful models like ROTHC to improve our understanding of earth system processes. The book concludes with chapters discussing microbial ecosystem functioning in wetlands under disturbance, including in the Arctic where rapid warming is challenging our ability to understand microbial sensitivity to seasonal dynamics and climate change.

Trends in P, Cd, F and U at SQM sites in the Waikato region 2007–2015

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The agricultural industry and international trade dominate the economy in New Zealand, and fertiliser applications are essential for successful agricultural production. Fertilisers are applied by thousands of farmers across New Zealand and in many countries around the world, but fertilisers also contain contaminant trace elements, such as cadmium (Cd), fluoride (F) and uranium (U), as well as the major nutrients, such as P. Mineral P fertilisers can be considered as an important source of contaminant trace elements in agricultural soils.

Continuous monitoring programmes, such as Soil Quality Monitoring, are invaluable for assessing the fate of trace elements in fertilisers as they allow enough time for cumulative applications of fertiliser to reach a critical mass loading. Monitoring of acid recoverable P, Cd, U and total F in soils of the Waikato region has been carried out regularly since 2005 and irregularly before that. Soil monitoring currently consists of 150 soil quality monitoring sites covering the major land uses and soil types in the region. Site selection and sampling follow national guidelines administered by the Land Monitoring Forum. Samples consist of a composite of 40–50 plug samples (2.5cm by 10cm deep) from a 50m transect on a consistent landform. Thirty sites per year are sampled, so it takes 5 years to samples all 150 sites. Data are presented as 5-year rolling averages of all 150 sites.

Results show averaged values for Cd, F and U tend to follow P, although behaviour depended on land use, e.g. horticulture sites showed increases in all 4 elements, but diary sites show decreases in P, Cd and U, while total F remained constant. Potential explanations for observations and the fate of these contaminants are discussed.

Effect of lime and compost on fluorine bioavailability and microorganisms in New Zealand horticultural soils

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Over a prolonged period of time with regular applications of superphosphate fertiliser to agricultural land, fertiliser-derived fluorine will gradually accumulate in the soil. There is potential for this increased load of soil fluorine to detrimentally affect soil biological processes. Increased understanding of the immediate impact of fluorine on soil microorganisms is therefore, crucial to assess the risk of F to soil biological functions such as nitrogen fixation by Rhizobium.

To assess the variability of soil fluorine between soil types as a function of soil properties, a field experiment has been designed that will analyse the level of fluorine in the horticultural soil at locations in the Manawatu, Pukekawa and Canterbury. Each field location has a long history of superphosphate application. In each location, soil pH levels ranging from 5.6 to 7.0 will be achieved by the addition of fine elemental sulphur (100% S) and Aglime (80% CaCO3). Amendment rates to of sulphur and lime have been determined based on a detailed preliminary laboratory incubation study. A commercial compost is to be applied at a range varying from 0 to 50 ton/ha to achieve different levels of organic matter in the soil. Periodical soil samples will be collected to measure soil F, total soil microbial activity, iron and aluminium concentration, and total phosphorus in the soil. The impact of elevated F on soil microorganisms, and soil and management factors affecting the availability of soil F at these three field conditions, will be presented in this paper. The potential to use lime and compost to control F bioavailability in the different soil types will also be discussed.

An economic perspective on soil amendment use for regulating cadmium bioavailability in horticultural soils

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Horticulture in New Zealand is a rapidly expanding industry, with exports recently growing to reach a record $4.3 billion. However, risks to this sector exist in the form of cadmium (Cd) accumulation within productive soils due to the Cd content of phosphate fertilisers, and their widespread repeated application. Exclusion from international markets can occur when foodstuffs exceed food safety guidelines for Cd as a result of production on contaminated soils. New Zealand's current system for managing soil Cd, the Tiered Fertiliser Management System, fails to account for variances in Cd plant uptake across soil types, crop species, and soil chemical and biological properties. There is a need here to establish risk based guidelines which cater to New Zealand's vast range of horticultural environments. As soil pH and organic matter content are the two primary soil properties controlling Cd bioavailability, manipulating these variables using lime and compost amendments can have beneficial effects by limiting Cd plant uptake. A cost–benefit analysis is being designed to determine whether using lime and compost amendments to manipulate these soil properties, as is being tested within current New Zealand field trials, can effectively regulate plant uptake of Cd and is therefore a worthwhile solution to the issue of soil Cd contamination. This will aid in the development of operational risk based guidelines for New Zealand's horticultural soils, and work to maintain the sustainability of this key national industry.

Scaling down rainfall simulators to evaluate the fertilizer-related transport of phosphorus in surface runoff

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Freshwater contamination is an important environmental concern worldwide. Numerous initiatives are under evaluation to minimize water quality degradation, including changes in soil tillage, conservation practices and fertilizer technologies. The adoption of environmentally friendly fertilizer formulations aims to mitigate losses of phosphorus (P) in runoff. The effect of new fertilizer technologies (e.g. coating treatments) on runoff is usually evaluated using field or indoor soil trays under simulated rainfall. However, the number of treatments which can be evaluated with these large-scale trials is limited, because it is costly, labour intensive and time consuming given the apparatus and analyses involved. We built two rainfall simulators to compare their performances on P runoff evaluation: a regular-sized simulator (3 × 3 × 2.5m) for use with soil trays of 1 m length, following internationally accepted standards, and a smaller version (1 × 0.6 × 1m) for laboratory-scale assessments using soil trays of 0.5m length. Grass was grown in the soil trays to create a vegetative coverage prior to application of several P fertilizers. The artificial rainfall delivered on the 5%-inclined trays generated the runoff, which was collected at regular intervals. We found very good correlation in terms of P losses in the runoff between both simulators, regardless of the fertilizer type, solubility or coating. Thus, it is suggested that a smaller version of the conventional rainfall simulators can be used as a rapid, more flexible, easier and efficient way to evaluate the effect of fertilizer formulation on runoff losses.

Withholding grazing after irrigation reduces nitrous oxide emissions and soil damage

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Expansion of irrigation has led to large increases in pasture production in summer dry regions such as Canterbury and Otago, New Zealand, leading to increases in dairy production. However, for irrigated grazing systems, the impact of dairy cows on the risk of soil compaction and associated environmental concerns such as nitrous oxide (N2O) emissions is poorly understood. We have observed situations where dairy cows graze pastures while irrigation is applied i.e. soils are at saturation when grazed. Under such practices, treading will more likely compact and deform soils, reducing soil porosity and pore continuity. This can lead to restricted soil aeration and drainage, promoting N2O emissions. The objective of our study was to investigate whether the timing of dairy cow grazing following irrigation can be manipulated to reduce soil treading damage and associated N2O emissions from urine patches. To achieve this objective, we conducted a field trial where irrigation was applied weekly to pasture and N2O emissions were measured from a poorly drained soil that had been compacted and treated with urine either 0, 2 or 6 days following irrigation. The trial was conducted beneath a rainfall shelter to exclude rainfall inputs. Compaction increased soil bulk density and reduced total porosity and macroporosity in the top 5cm, with the level of damage decreasing with increasing withholding period. Compaction and urine application 0 and 2 days following irrigation produced relatively high N2O emissions, with corresponding emission factors (EF3) of 2.7% and 2.4%, respectively. In contrast, delaying compaction and urine until 6 days after irrigation substantially reduced EF3 to 0.9% due to a lower soil water content at the time of urine deposition. Our study suggests delaying grazing of irrigated soils can reduce N2O emissions and soil damage.

Ammonium adsorption properties of Australian zeolite in the presence of other ions

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Zeolites are aluminosilicate minerals with well-defined microporous structures and predictable ion exchange characteristics. Zeolites could potentially be used as an amendment to mitigate NH4+ emissions from manure, soil and wastewater due to its high cation adsorption capacity and preferential affinity to NH4+. A greater NH4+ adsorption efficiency has been achieved by modifying exchange sites of zeolites to sodium form with NaCl treatment. Most of the previous studies on ion exchange behaviour of zeolites were based on binary equilibrium experiments. However, generally, most mediums used in practical applications consist of varying compositions of multi-species ion cocktails, and detailed studies on how the presence of other ion species impinges NH4+ adsorption by zeolites are rare. Therefore, this study was conducted to determine NH4+ adsorption properties of Australian natural and sodium zeolites at high concentrations of N-NH4+ with a different combination of other ions: calcium (Ca2+) 600mg/L, magnesium (Mg2+)200mg/L, sodium (Na+) 600mg/L, potassium (K+)1000mg/L, phosphate(P-PO43-) 50mg/L, and acetate (CH3COO-) 300mg/L, at pH 7. The concentrations were decided according to the preliminary evaluation of anaerobically digested swine manure generated within the research lab.

The presence of other ions significantly altered NH4+ adsorption by zeolites. NH4+ adsorption by both Australian natural and sodium zeolites was reduced by 44% and 57% respectively in the presence of Ca2+, Mg2+, Na+, K+, P-PO43-, CH3COO- ions at pH 7. Although NH4+ adsorption by sodium zeolites was 25% higher than Australian natural zeolite in the NH4+ ion only solution, sodium zeolite has a similar potential to adsorb NH4+ as the Australian natural zeolites at the presence of Na+, Ca2+ and Mg2+ ions in the mixtures. However, these findings are indicating the potential applications in NH4+ recovery from livestock manure treatment systems which contain high ammonium levels and other ions.

Sharing soil data – Australian/New Zealand leadership in global soil data exchange standards

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Efficient exchange of standardised soil data is essential to support priority issues, including climate change adaptation, water quality, food security and a growing world population.

Modern information systems access and integrate soil data from a range of sources. Various initiatives support the need for consistent soil data by defining soil information models and data exchange standards. Examples include European INSPIRE, e-SOTER and ISO 28258:2013 standards; the GlobalSoilMap; and Australian and New Zealand ANZSoilML projects. The UNFAO Global Soil Partnership (GSP) recognises the value of these projects, particularly for Pillars 4 (Global Soil Information System) and 5 (Harmonization). However, due to relatively low capacity for operational uptake, soil data users are still required to individually reconcile multiple sources of data and systems.

The IUSS Working Group on Soil Information Standards (WGSIS) was established in 2010 to merge existing information models into a set of standards for the exchange of globally consistent soil data. The WGSIS demonstrated the value of this work through an Open Geospatial Consortium (OGC) Interoperability Experiment and is working with the GSP to further progress this initiative.

Australian and New Zealand development of a regionally applicable soil data exchange standard, ANZSoilML, provides leadership to the global effort. ANZSoilML has been used to implement a number of soil data services (OGC web feature WFS and web coverage WCS) within Australia and New Zealand. These services provide web accessible data that is being used in a growing number of applications developed by government and agricultural organisations. The OGC Soil Interoperability Experiment and ANZSoilML services show what is technically possible. There is limited capacity to progress this work at a global level; however, proliferation of different data standards will not result in data interoperability and the benefits of improved access, sharing and use of soils data will not be realised.

Gender, diversity and careers in soil science: What do our members think?

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Women currently make up more than 50% of bachelor degree completions in the physical and natural sciences; however, workforce census data shows that this has not translated to equal proportions of women and men in senior positions in the science, technology, engineering, mathematics and medicine (STEMM) disciplines. To address this imbalance, the Science in Australia Gender Equity (SAGE) initiative was launched in 2015 by the Australian Academy of Science and the Australian Academy of Technology and Engineering.

In 2014, a survey was sent out to financial members of Soil Science Australia with the aim to i) understand the current situation with respect to equity and diversity in Soil Science Australia, ii) understand the perspectives and experiences of society members on key equity and diversity issues, and iii) identify key actions for Soil Science Australia to pursue.

One hundred and sixty-nine members responded to the survey (~18% response rate), of which 40% were female, 59% were male and 1% identified as neither gender. When asked about the Society's culture with regard to inclusivity at Society events, award nominations, recognition in the Society and nomination for Branch and Federal Council positions, responses were overwhelmingly positive. Fifty-nine percent of respondents supported the formation of an equity and diversity group in the society, and the comments provided were either positive or not negative. Conversely, the comments provided by the respondents who did not support the formation of an equity diversity group were mixed.

Respondents identified sub-conscious gender bias and family responsibilities as potential barriers to career progression in soil science. Members of Soil Science Australia generally wanted to continue in their careers as soil scientists and enjoyed their work but also identified a number of barriers that may prevent them from doing so, such as a lack of job security.

Soil properties changed with forest stand treatments in eucalyptus plantation in South China

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The ecological impacts of eucalyptus plantations (EPs) have garnered increasing attention. Compared with natural forests, EPs have relatively simple structure and caused declines in soil quality. To maintain a sustainable forest ecosystem, forest managers attempt to convert EPs into mixed forests. However, effects of such stand treatments on soil quality are poorly understood. Here we investigated soil property change with eucalyptus monoculture conversion into mixed plantation. This study was conducted at the Dalingshan Forest Park in Dongguan City, Guangdong, China. A stand conversion experiment was established in a 15-year-old EP in 2008. The plantation treatment methods were: evenly removing 30% of eucalyptus trees followed by planting native broad-leaved trees in the canopy gaps (Mode I), and evenly removing 60% of eucalyptus trees followed by planting native broadleaved trees in the gaps (Mode II). The un-thinned plantation served as control (CK). Effects of stand treatments on soil nutrients were assessed seven years after the conversion. Results showed that compared to control, Mode II significantly increased SOM, total potassium, and available potassium in 0–20cm, 20–40cm, and 40–60cm soil layers. Moreover, Mode II had 71% more total nitrogen, 77.4% more available nitrogen, 94.2% more available potassium, and 71% more soil organic matter than CK in 0–20cm soil layers. Total and available nitrogen, potassium, and phosphorus contents in 0–20cm, 20–40cm, and 40–60cm soil layers of Mode I did not differ significantly from CK. A significant increase occurred only in the content of SOM in 20–40cm soil layers of Mode I compared with CK. Soil pH did not differ among the control, Mode I and Mode II. Our results suggested that thinning 60% of eucalyptus trees and inter-planting of native broad-leaved species in EPs was beneficial to increase soil nutrients and SOM.