BRITISH SOCIETY OF SOIL SCIENCE

The British Society of Soil Science

Annual Conference 2024

Sustainable Soils for People and Planet

Wednesday 4, Thursday 5 and Friday 6 December 2024

Glamorgan Cricket Club, Sophia Garden, Cardiff

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Annual Conference 2024 Abstract Book

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BRITISH SOCIETY OF SOIL SCIENCE

Annual Conference 2024 Abstract Book

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Speaker Biographies

Rachel Boulderstone - DEFRA

Rachel Boulderstone heads up the Soil Health and Contaminated Land policy team within the General Environment Directorate of Defra. Rachel has led on soils for the last four years, but with over 20 years' service at Defra on a wide range of policy areas including waste management, flood management, sustainable drainage systems, environmental targets and now soils. In particular, developing policy for the Flood and Water Management Act 2010, the Agriculture Act 2020 and the Environment Act 2021, the Environment Improvement Plan as well as numerous secondary legislation amendments. Rachel has a particular interest in surface water flooding due to soil erosion and compaction on both agricultural and urban soil and promotes the importance of encouraging the right practices relevant to soil type and land use that support production, environment and biodiversity.

RJ Cooke - Welsh Government

RJ Cooke leads the Peatland, Soil and Agricultural land Use Planning team within the Environmental Sustainability Directorate of Welsh Government. He has led on the development of the National Peatland Action Programme since 2019. His wider team covers a wide range of evidence, policy and technical advice including the Soil Policy Evidence Programme, development of a Soil Policy Statement for Wales, and representing soils through the planning systems in Developments of National Significance and mineral extraction cases.

Sarah Buckingham – Scottish Government

Sarah is a senior consultant with SAC Consulting (part of Scotland's Rural College) with expertise in sustainable land management practices for soil health, soil carbon sequestration and agricultural greenhouse gas mitigation. Sarah has 12 years soil research experience before joining SAC Consulting's Environment Team in 2022. Sarah is currently on secondment to Scottish Government (June 2024- March 2025) working with the Climate Change Adaptation Team on a ClimateXChange funded fellowship called "Securing Scotland's Soils in a Changing Climate" which aims to develop a routemap for supporting the protection of soil across Scotland.

Colleen Ward - AFBI

Colleen Ward is Project Manager on the Soil Nutrient Health Scheme at the Agri-Food and BioSciences Institute (AFBI).

She is an Experienced Project Manager with a demonstrated history of working in the research industry, and has experience in Environmental Compliance, Environmental Engineering, Sustainability, Water Quality, and Environmental Policy.

Bob Klein Lankhorst - Royal Eijkelkamp

Expert in soil health and sustainability, with a focus on innovative technologies that help land managers better understand and improve soil health.

David Reay - CPL/Puragen Activated Carbons

David Reay is Head of Strategic Partnerships for CPL/Puragen Activated Carbons. He graduated with a Master's Degree in Chemistry and has enjoyed a varied and interesting commercial career in a number of industrial sectors, including chemicals, automotive and aerospace. He has held senior strategy/marketing roles in the activated carbon industry for over 16 years and is a Member of the Chartered Institute of Marketing. He is passionate about environmental issues and is an experienced public speaker. He particularly enjoys communicating the numerous applications and benefits of activated carbon purification technology.

Abi Reader - NFU Cymru

Newly elected 2022 NFU Cymru Deputy President Abi Reader at NFU headquarters, Agriculture House, Kenilworth, England, United Kingdom on March 01, 2022. Credit: Lawrence Looi / NFU[/caption]Abi Reader is a third generation mixed farmer, farming in partnership with her parents and uncle in Wenvoe just outside Cardiff. Goldsland Farm is home to 200 milking cows, 100 sheep, 20 beef cattle and 120 acres of arable. The farm has also recently started an Agroforestry trial site and set up a small scale horticulture venture. Abi is the current NFU Cymru deputy president, co-founder of Cows on Tour, an Open Farm Sunday host and Woman Farmer of the Year 2024 with National Women in Agriculture Awards. In 2019 Abi was awarded an MBE by the Queen for Services to Agriculture.

Richard Anthony - Farmer

Richard Anthony and family farm 3,000 acres of arable and grass with a flock of 800 ewes. A pioneer of sustainable intensification, Richard's focus on soil management has seen yields increase by 25-30% and the earthworm population tenfold. Soil structure and fertility have been improved through no-till direct drilling, and minimum tillage, cover crops and companion planting of spring beans and purple vetch to fix nitrogen and buck wheat to mine phosphate for oilseed rape. As well as helping with increasing soil organic matter this helps deterring flea beetle and pigeons. Insecticides haven't been used for three years. He continues to develop regenerative systems, favouring natural solutions over chemical inputs, resulting in a farm rich in wildlife including rare yellow wagtails and turtle doves.

Dr Non Williams – Farming Connect

MENTERA Ariennir gan Lywodraeth Cymru Funded by Welsh Government

Dr Non Williams has significant experience of the agricultural industry, from an employment, research and personal perspective. She works for Mentera as the Carbon Specialist Officer for Farming Connect (Welsh Government funded Knowledge Transfer Programme for Farmers and Land Owners). Non is responsible for developing, implementing and leading on numerous innovative projects within her area, which includes Farming Connect's Pan-Wales Welsh Soil Project.

Prof. Jenni Dungait – European Journal of Soil Science

Professor Jennifer Dungait is a member of Council as Editor in Chief of the European Journal of Soil Science (since 2019).

She is an Honorary Professor of Soil Science at the University of Exeter and Honorary Professor of Soil Biogeochemistry at Scotland's Rural College (SRUC), Edinburgh. Jenni is a freelance soil scientist with clients in the agricultural sector and academia (Soil Health Expert, since 2018). Previously, she worked as a soil science researcher at the University of Bristol (2005-2008) and Rothamsted Research (2008-2018). She was a Visiting Scholar at the Carbon Mitigation and Sequestration Center (CMASC) at the Ohio State University in 2012.

Martina Girvan - Arcadis

Martina is a Chartered Ecologist with over 25 years' experience who specialises in biodiversity, ecosystem services and natural capital. In addition to leading the Ecology and Arboricultural team, her role within Arcadis is to promote the implementation of the natural capital approach to deliver biodiversity and environmental net gain within projects, for clients and different technical disciplines. To this end she works with organisations such as CIEEM, CIRIA and the Green Construction Board to produce guidance, develop and champion events, to promote the use of quality engagement and design including nature-based solutions to deliver climate resilience, social cohesion and enhanced biodiversity, improving quality of life for all.

Aydin Zorlutuna – Arcadis

Aydin provides strategic leadership to the ARCADIS UK region Landscape Architecture, Masterplanning and Urbanism team. With over 30 years experience he is a well seasoned and client facing professional who enjoys working with fellow disciplines and artisans alike. Aydin has been guest lecturer at the University of Gloucestershire, and has presented thought leadership at conferences and network events. He has successfully presented on numerous occasions to Design Review Panels. He is a qualified Permaculture designer and a professional assessor for the Landscape Institute's Pathway to Chartership (P2C) and Technician Member attainment process.

Mark Nason – CIEEM

Mark has worked in education and research for over 20 years. At Bangor University, he completed a PhD in soil organic matter formation at post-industrial sites, followed by two post-doctoral research positions in plant physiology and soil construction for land restoration. After moving into Further Education, he qualified as a teacher and has worked for the Chichester and Cornwall College Groups. In his earlier roles, he lead the development of applied Higher Education courses at Eden Project Learning, teaching plant-soil science to horticulture and ecology students, and maintaining a strong interest in soil construction and the development of soil processes during restoration. He is now the Head of Professional Practice at the Chartered Institute of Ecology and Environmental Management (CIEEM).

Prof. Dave Chadwick – Bangor University

Dave Chadwick is an Agriculture and Environmental Scientist with research interests that include sustainable use of nutrient inputs, diffuse pollution measurements and the testing of mitigation strategies in different farming systems. He is Professor of Sustainable Land Use systems at Bangor University, and led the Defra/Devolved Administrations-funded InveN2Ory project (AC0116) to improve the nitrous oxide component of the UK's agriculture greenhouse gas inventory and was PI of the NERC-funded Uplands-N2O project (NE/M015351/1) to determine factors that control nitrous oxide emissions from urine patches in extensively grazed upland systems. He is Co-I of two of the UKRI (BBSRC)-funded Greenhouse Gas Removal Demonstrator projects and he co-leads the GCRF-funded project, *Do agricultural microplastics undermine food security and sustainable development in developing countries*?

Dr. Marta Cattin - Environment Agency

Marta has a PhD in Soil Science from Lancaster University and has been with the Environment Agency for the past three years. She started out as a Soil Health Advisor, working with farmers on an EU LIFE project in the North East of England aimed at improving soil management practices.

During her time as Soil Health Advisor, Marta ran a soil health monitoring program in the Northumberland catchment area, helping farmers understand their soil health and encouraging them to adopt

better practices. She's also set up two field experiments—one looking at cover crops as green manure and another testing composted pig FYM as a soil bio-stimulant—to show farmers practical ways to improve soil management on their land.

Gareth Jenkins - Wiley

Gareth Jenkins is a full-time editor at Wiley, based in the UK. His PhD is in Aquatic Ecology – it focussed on trophic networks, particularly in freshwater ecosystems, and their response to multiple stressors, such as acidification and temperature. Gareth was Editor-in-Chief of Ecology & Evolution between 2017 – 2024, and has recently moved to Executive Editor on the title, as well holding the same role on the Journal of Biogeography since 2023. Within research publishing, he has a particular interest in open data and code.

Jack Connolly – Manchester University

Jack Connolly is a Research Fellow at the Manchester Institute of Biotechnology, School of Natural Sciences, Faculty of Science and Engineering at the University of Manchester. He has a keen interest in the development of novel genome editing technologies in soil bacteria, starting from his PhD, which focussed on in vivo engineering of antibiotic production. Following this, Jack worked as a postdoctoral researcher at the University of St Andrews, at the interface of chemistry and biology in natural product biosynthesis. In 2020, he joined the NERC/NSF Signals in the Soil project led in the UK by Prof. Eriko Takano at the University of Manchester. This project, joint with the University of Minnesota, USA, sought to further our understanding of intercellular signalling in soil microbiomes.

Dr Elena Vanguelova – Forest Research

Dr Elena Vanguelova is a senior biogeochemist and the lead of the Soil Sustainability Research in Forest Research. Her research over the past 20 years covers forest soil functions and health with particular focus on forest and soil carbon and nutrient storage, stability and cycling as well as soil biodiversity and soil health indicators. She has led and collaborated in numerous UK and EU based projects, initiatives and research networks and she is the lead of the UK

BioSoil forest monitoring network, part of EU ICP Forests. She has been sitting on the EU forest soil expert panel for over 20 years and leads the Forest soil condition and health monitoring network as part of the tNCEA (Terrestrial Natural Capital Environmental Assessment Programme).

Dr Andrew Weatherall MICFor – RSPB

Andrew grew up in a place with more lamp posts than trees. He has a forestry degree from Aberdeen University, a PhD on nutrient cycling in (Sitka spruce) forests, from the Macaulay (now James Hutton) Institute, he led the Forest Management degree at the National School of Forestry in Cumbria and developed the Woodland Ecology and Conservation degree. He contributed to the Woodlands chapter of the British Ecological Society's report on Nature-Based Solutions and led a working group defining Climate-Smart Forestry in a European funded research collaboration. He now leads woodlands and forestry policy for the RSPB and is a member of the ICF's Environment Special Interest Group.

Clive Thomas - Soil Association

Clive Thomas is Soil Association's senior adviser for forestry, leading on regenerative forestry advice including the integration of trees and woodland management into farming systems, as well as policy development in response to voluntary carbon and natural capital markets. Clive is a fellow of the Institute of Chartered Foresters and has worked in private and state forestry sectors during a 30+ year career managing forests and developing forest policy. As well as his advisory work, Clive is an experienced forestry trainer, delivering courses and workshops on a wide range of topics under the Soil Association's regenerative forestry theme, including agroforestry, FSC® accredited courses and responsible forest management capacity building for partners in the UK and around the world.

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Nutrient Management: Oral Abstracts

Influence of phosphorus fertiliser on soybean nitrogen fixation and production

By **Hannah J. Walling**[1], *Shane A. Rothwell*[1], *Phillip M. Haygarth*[1], *John N. Quinton*[1] and *Mariana C. Rufino*[1,2]

1. Lancaster University
2. University of Munich

Demand for soybean production is continuing to increase, one potential way to meet this demand is through improved N2 fixation efficiency, we are suggesting this can be achieved by optimising phosphorus (P) fertiliser use. Phosphorus is an essential nutrient for nodule formation and function, with adequate P supply being required to optimise N2 fixation and improve soybean yield.

We are hypothesising two potential pathways in which optimal P supplies (in this case achieved through P fertiliser application) will lead to enhanced N2 fixation: (1) P addition will drive an increase in nodule formation, through increasing photosynthetic capacity and resource accumulation and allocation, and (2) P addition will drive an increase in nodule function, through increased rhizobia efficiency and increased rates of fixation. We hypothesise that the two pathways may not be working in isolation, rather it may also be a combined response comprising of mechanisms from both. We aim to provide process-based observations of whole plant response to P addition, highlighting correlation between processes involved in achieving increased rates of N2 fixation.

Preliminary results suggest that nodule trait response through nodule formation is driving an increase in N2 fixation following P addition; however, work is currently ongoing and will be presented at the symposium. The results of this study will enable better mechanistic understanding of the role of P in improving soybean N2 fixation, allowing for improved nitrogen use efficiency and crop productivity.

Keywords: Soybean, phosphorus, production, nitrogen fixation, nodule, fertiliser

Funded by: Corteva Agriscience

Green shoots from blue growth: promoting the circular blue-to-green economy through repurposing aquaculture by-products to remediate wastewaters and create sustainable soil amendments

By **Rose Boyko**

Scotland's Rural College

The fertiliser sector is facing a cliff-edge – global terrestrial rock phosphate mines are expected to be depleted within the next 50-100 years. Phosphorus (P) is an essential nutrient for agriculture and key fertiliser ingredient that has scope to be provided to cropping systems from alternative sources. The utilisation of two waste streams has the potential to bring the sector back from the edge. The UK shellfish and aquaculture industry generates huge volumes of waste and the adsorbent nature of this waste (seashell and crab shell) has scope to uptake essential nutrients (like P) from wastewater treatment centres, another area of nutrient waste in modern systems. The aim of this research is to investigate how a marine 'waste' product which has been repurposed to add-value will react in soil and act as an alternative fertiliser. A crab carapace material (CCM) treated with potassium hydroxide to increase surface absorbency was used to remove P from wastewater treatment systems in previous research. In the current phase of this project, Scottish grassland, arable and forestry soils that were low in pH and available-P were used in CCM incubation experiments to test the material's ability to deliver soil available-P requirements when compared to conventional fertilisers. Preliminary results show that the CCM delivered plant available-P, but also significantly increased soil pH values. Both granular and powdered forms of CCM were analysed, and both delivered successful increases in both indices. Further results will be available in the coming weeks and presented at the conference. Implications of the development of this and other CCM products will support phosphate circularity in the UK, the repurposing of organic wastes that would otherwise be directed to landfill and establishing more 'locally' generated fertiliser alternatives – thereby reducing the carbon footprint of UK agricultural activities.

Funded by: Co-op Carbon Innovation Fund

Grain P concentration as an indicator of fertilizer requirements in winter wheat

By **Stephan Haefele** and Steve McGrath

Rothamsted Research

Available phosphorus management is a continuous task in wheat-based systems of the UK, balancing between enough P application to support high yields and not too much application to avoid damaging losses to the environment. Although the Olsen P method with corresponding threshold values is well established, the method does have a considerable uncertainty interval and the response on different soil types can vary. Therefore, grain P concentration and corresponding threshold values were proposed as a new method for P management. We used data from longterm experiments at Rothamsted Research to investigate the relations between grain yield, grain P concentration, and Olsen P values in winter wheat crops over the last 30 years. Our results show that maximum grain P concentrations in high yielding years are lower than in low yielding years, indicating a dilution effect through high assimilate transfer to grains. A minimum threshold of not more than 0.25% grain P was indicated in our experiments, above which no further significant yield response occurred. And an Olsen P threshold value of 15 mg P per kg soil seemed to be sufficient to avoid P deficiency even in highest yielding seasons for winter wheat in the investigated trials. However, the analysis also indicated that current grain and straw P concentration values of winter wheat, used for field specific P balances, are outdated and need adjustment. Using these results can help to finetune field specific P management for optimized crop P supply and minimized P losses to the environment.

Funded by: BBSRC

Nutrient Management: Poster Abstracts

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Teaching agricultural soil biology to support sustainable crop production under pending climate change conditions by semi-saline irrigation

By **Anais Chanson,** Matthew Goddard, and Iain Gould

University of Lincoln

With rising sea levels and increasing summer droughts due to climate change, ground water and soil in temperate coastal areas are increasing in salinity, forcing farmers to use the saline ground water to irrigate crops in summer. Moreover, the short- and long-term effects of soil saltwater contamination on soil microbial communities in temperate areas have not yet been thoroughly investigated. Here we developed a 3-year experiment to study the effects of different levels of semi-saline irrigation on crops and soil microorganisms and test the hypothesis that semi-saline irrigation across the growing season applies a selection pressure to pre-adapt soil organisms to increased soil salinity. The aim is to determine if we can pre-prepare soils for future climate change conditions. After the first year the data shows that irrigation with higher levels of semi-saline water (6 dS/m) had a negative impact on spinach yield, but that irrigation with medium levels of salinity (3 dS/m) had no negative impact on crop yield compared to the control. Our results also show that increased salinity levels had an impact on the structure and function of soil bacterial and fungal communities, using DNA and RNA sequencing. The lack of effect on crops at 3 dS/m part-saline irrigation but the change in microbial community structure and function suggests the selection pressure imposed by this part-saline irrigation level across the growing season has driven the soil biology community change to a state where it is better adapted to the increased salinity. This is in line with the hypothesis that soil can be taught to be more tolerant of future climate change conditions. More generally, this is the first proof in principle of the concept of pre-adapting soils to future conditions: a method of mitigating the effects of climate change to ensure sustainable food production for future generations.

Funded by: UKRI

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Nitrogen Pathways in Cover Crops: Interim Findings from a Three-Year Study

By **Bethany Fairley,** Tom Ormesher, and Stephen Woodley

Southern Water

This study explores the dynamics of mineralised nitrogen uptake in cover crops, focusing on overwinter nitrate leaching and nitrogen availability for the following spring barley crop. The three-year trial, conducted across two sites, compares three cover crop mixes: soil structure, vitality, and oats/vetch. Initial results from the first two years indicate that complex cover crops (vitality and soil structure) reduced nitrate leaching by an average of 13 kg N/ha compared to overwinter stubble, while oats/vetch cover showed 18% more nitrate leaching (+3.7 kg N/ha) than stubble. Oats/vetch plots provided 11.4 kg N/ha of soil mineral nitrogen (SMN) to the following crop, which is more than the vitality mix (8.5 kg N/ha) but less than the soil structure mix (17.7 kg N/ha). This suggests that factors such as legume content may influence nitrogen availability for the subsequent crop, rather than solely nitrate capture in biomass. Complex mixes retain significantly more nitrogen in above-ground biomass, with the soil structure mix capturing the highest levels. On average, cover crops provide an additional 12.5 kg N/ha of soil nitrogen supply compared to overwinter stubble. The data suggest that while simple cover crops capture less nitrogen and allow more leaching, complex mixes are more effective at reducing overwinter nitrate losses and supplying nitrogen for the following crop.

Keywords: nitrogen, cover crops, nitrate leaching, mineralised nitrogen, soil structure, vitality mix, oats/vetch, spring barley, soil nitrogen supply, sustainable farming

Funded by: Southern Water, Kings

Link to Poster

Research GAP analysis for the use of farmed insect frass as a fertiliser

By **Felicity Crotty,** Liam Rock, and Dave Freeman

Ricardo - Agriculture and Land team

In natural habitats, insect frass (faecal pellets and moulted exoskeletons) has been found to be a major component of some soils, accelerating organic matter turnover and improving plant growth. Farmed insects produce large quantities of frass as a by-product which could be used as a fertiliser or soil amendment; with the growth of insect farming understanding its usefulness is essential. To develop our understanding of the use of farmed frass as a fertiliser, a gap analysis was conducted using a rapid evidence assessment methodology. Searches via Google Scholar for "frass" yielded thousands of results (79,300), including many review papers (32,000), these were reduced via screening. Studies have focused on the impact of frass fertiliser amendment in seed germination and plant growth, in arable and horticultural sectors, as well as grasses. Some studies compared frass to other organic amendments, whilst some focused on the comparison with artificial fertiliser. Through analysis of these papers, three key research gaps were highlighted. Firstly, there needs to be more standardisation of the nutrient composition (feedstock used to farm insects) as this alongside differences in storage greatly impact the usefulness of frass as a fertiliser. Secondly, there is no consensus on rates of application and there is a paucity of research performing field trials. Thirdly, and crucially there needs to be a thorough investigation of the impact of frass application as a fertiliser at field scales on the wider environment understanding the fate of nitrogen, its impact on soil GHG emissions and interactions with the resident soil biology; as this area has been largely overlooked within academia. Globally, research is being undertaken to ascertain the efficacy of insect frass as a fertiliser, but until these three research gaps have been investigated, the usefulness and safety of frass being spread in large quantities over farmland is unknown.

Funded by: DEFRA

Sediment Budgets in The River Derwent, Yorkshire: soil erosion modelling

By Richardson, J.1*; Brown, H.2; Keevil, G.M.2; Aston, B.3; Hodgson, D.M.2

*1 – Edge Hill University, * Janet.Richardson@edgehill.ac.uk*

2 – University of Leeds

3 – Yorkshire Water

Understanding soil erosion, and the transport of soil / sediment through fluvial catchments is fundamental when thinking about holistic catchment management including interventions to manage water such as Natural Flood Management e.g., buffer strips. The River Derwent, Yorkshire has a recognised fine grained sediment problem, impacting water treatment costs, however there is little information within the catchment related to source areas of sediment including soil erosion. Much of the catchment is dominated by agriculture (40%) and lowland areas (51% <57m). The catchment is complex and contains 14 soil types delineated by European Soil Database. The Soil Water Assessment Tool (SWAT) was used to model soil erosion within the catchment to understand the wider sediment budget of the River Derwent and calibrated using gauge records using SUFI 2. The model, which integrates soil information such as texture, organic matter, saturated hydraulic conductivity and soil erodibility (K). SWAT showed distinct variation across the catchment, with lower than expected volumes contributed from the middle and lower catchment; especially in areas surrounding the main trunk river of the Derwent; 80% of sediment yield relates to the Upper Rye and Upper Derwent. Overall, the modelling shows the River Derwent contributes 12% of the wider Ouse Catchment sediment budget. In-channel samples were collected and tested for water quality parameters such as total suspended solids, turbidity, nitrate. The in-channel samples show locally soil erosion is important, however at a catchment scale flow rate is the limiting factor for fine-grained sediment entrainment. Thirty years of weather data was integrated into the SWAT, however, questions relate to extreme events and thresholds within the model to initiate soil erosion, especially as more extreme localised events are predicted due to climate change.

Keywords: modelling, soil erosion, climate change, sediment budgets, natural flood management

Link to Poster

Application of Composted Pig Manure in Northern England: Effects on Soil Health and Nutrient Turnover

By Marta Cattin

Environment Agency

Application of composted farmyard manure (FYMc) to agricultural soils has the capacity to improve soil health properties, such as soil organic matter, water holding capacity, soil structure and aggregate stability. Moreover, the organic form of nitrogen (N) contained in FYMc can be slowly mineralised and become available throughout the growing season. However, farmers are still uncertain on the efficiency of N mineralization rates from FYMc, thus this tends to not be included into a nutrient management plan. Therefore, as part of the EU LIFE WADER project, a three-year field experiment (2023-2026) was established on a clay loam soil in Northumberland (UK), with the aim to investigate the soil health benefits and fertiliser potential of FYMc vs unamended soil (control, Ctr), on winter wheat (WW). During 2023-2024, WW leaf tissue samples were collected in order to investigate the response of the crop to the treatments; soil samples were collected and analysed for chemical and biological indicators prior to ammonium nitrate top dressing on WW; grain yield was measured during harvest. A nutrient management plan was calculated, and the amount of potentially mineralizable N applied to the WW amended with FYMc, was deducted from the top dressing. Preliminary results indicate the application of FYMc has increased the soil ammonium content by 143% and reduced the soil nitrate content by 27% compared to Ctr, whilst no effect on leaf tissue or soil biological indicators were observed. During harvest, FYMc WW yielded 11% more than Ctr. Our research demonstrates that application of FYMc to clay loam soil can slowly release available N which can help reduce the N inorganic fertiliser application during top dressing, without negatively influencing the WW yield. The initial findings will be validated throughout the remaining two years of experiment.

Key words: composted pig manure, nutrient turnover, soil health, winter wheat

Funded by: EU LIFE Programme

Link to Poster

Peri-urban farming and wastewater irrigation in Faisalabad, Pakistan: friend or foe?

By Patrick McKenna

Cranfield University

Peri-urban farming is expanding in Faisalabad and farmers are increasingly looking to wastewater for irrigation. Wastewater provides a rich source of organic matter and crop nutrients, but it is also contaminated with heavy metals from the textile industry. Heavy metals such as Cadmium and Lead can accumulate in soil over time and restrict crop yields whilst endangering the health of people consuming food grown on contaminated soil. Biochar applications to soil may have the capacity to mitigate the contamination risks associated with wastewater irrigation.

Three field trials were established on peri-urban farms in Faisalabad in 2020. Leaf, root and fruit crops were cultivated(lettuce, beetroot and tomato) and three irrigation treatments were applied (clean water, wastewater and biochar-treated wastewater). The biochar was produced from Acacia biomass and was applied to soil at 10 t DM ha. The presence of a selection of heavy metals in soil was assessed after the growing season for three years. The metals selected were Cadmium, Copper, Chromium, Lead, Nickel, Mercury and Zinc.

The final assessments indicated that the concentrations of most heavy metals had increased in the wastewater treatment, with no significant changes in the clean water treatment. The biochar treatment was shown to have significantly lower heavy metals than the wastewater treatment, indicating the potential for biochar to absorb heavy metals from wastewater. No significant effect of crop was observed on soil heavy metals.

The results demonstrate the importance of soil monitoring when wastewater is being used for irrigation, and that the contaminant-binding properties of biochar makes it a promising and cost-effective means to reduce the contamination risks associated with wastewater irrigation in Faisalabad.

Funded by: UKRI Global Challenges Research Fund

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Soil For Net Zero:

Oral Abstracts

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Net ecosystem productivity of a UK cropland over 2.5 years

By Isobel L. Lloyd[1], *Ross Morrison*,[2] *Richard P. Grayson*[1], *Marcelo V. Galdos*,[3] and *Pippa J. Chapman*[1]

(1) School of Geography, University of Leeds

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To combat climate change and meet net zero targets, agricultural soils must sequester carbon (C) whilst providing sufficient food for the growing human population. Despite this being widely recognized, there is a significant lack of data on the extent of C losses and gains between croplands and the atmosphere associated with the growth of different crops, particularly in the UK. In response to this, the eddy covariance technique was used to measure net ecosystem exchange (NEE) of carbon dioxide (CO2) and the net ecosystem productivity (NEP) calculated of a UK cropland over 2.5-years, which included the growing seasons of maize, winter wheat and vining pea. Net ecosystem productivity showed the cropland was losing C during the maize growing season (136 g C m-2), but was acting as a C sink during the winter wheat and vining pea growing seasons (-148 g C m-2 and -154 g C m-2 respectively). Over the complete 2.5-year measurement period, which included fallow periods when there was no crop in the ground, the cropland was a net C source (208 g C m-2) to the atmosphere. This highlights the importance of measuring NEE and NEP during non-productive fallow periods as well as crop growing seasons when estimating cropland NEP. For agri-ecosystems to accrue C, the amount of C added to the system must be greater than all other losses of C as exported biomass and the ecosystem respiration. Increasing C imports by adding organic fertilisers, retaining a greater proportion of crop residues in the field, and/or growing cover crops during fallow periods have the potential to reduce C losses from agri-ecosystems in the UK.

Key words: maize, pea, winter wheat, carbon flux, soil, net ecosystem productivity

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An Estimation of Network Rail Soil Carbon Stocks Based on Data from Disused Rail Lines

By Justin Thomas, (University of Aberdeen), Astley Hastings, Jon McCalmont (University of Aberdeen), Neil Strong (Network Rail Ltd), Zoe Wright (Lancaster University)

Technosols are those soils strongly impacted by anthropogenic activity and containing significant amounts of artefacts. They include soils formed through urbanisation, mining, industrial processes and the creation of transport infrastructure. They cover an estimated 7% of the UK and given their heterogeneity and varied settings are often excluded from soil carbon accounting. The rapid 19th Century expansion of the UK rail network created nearly 30,000km of narrow ribbons of Technosols across the country. Today, the infrastructure managed by Network Rail covers over 51,000 ha. This study examines the soil organic carbon (SOC) content of disused railway lines in Great Britain, as an accessible proxy to the active estate, and assesses the potential factors influencing its distribution and density. The dataset is based on 335 cores taken to a maximum depth of 30cm collected from 87 sites across England, Scotland and Wales. We find that the mean average SOC concentration per core is 5.0 % yielding a mean average SOC stock of 49.7 t C ha-1. There is a clear decrease in SOC with depth through the top 30cm. The data are highly variable but bulk density, moisture content, soil texture, underlying bedrock, adjacent soil type and habitat are statistically significant factors influencing SOC. Climate has a smaller impact while railway structure, location, elevation, construction and abandonment dates do not appear to be significant. Explanatory models can account for much of the variation encountered (R2=0.71). A reduced factor model based on parent material and habitat (R2=0.17) has been used to create a SOC map of the active rail network and generate an estimate of the current soil carbon stock of the Network Rail estate at 1.6 million tonnes, equivalent to 30.6 t C ha-1.

Keywords: SOC, Railway, Technosols, Soil, Network Rail, Model

Funded by: University of Aberdeen

The effect of slurry treatments and spreading techniques on soil N_2O emissions

By Khagendra Raj Baral1*, James Perkins[1], Ewan McCutcheon[1], Shannon McIvor[1], Karl Richard[2], John McIlroy[1]

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The sustainability of Irish agriculture depends on the closing of nutrient cycles by minimising the losses of nutrients from agricultural nutrient sources. Animal slurry is rich in plant nutrients and can be an alternative to mineral fertilizers in its raw state or with subsequent treatment such as through anaerobic digestion. Ammonia volatilization from slurry or anaerobic digestate spreading is a major concern within Irish agriculture. Low emission spreading techniques and slurry acidification have been shown to decrease ammonia from landspreading. However, the impact of low emission spreading techniques and acidification on nitrous oxide (N2O-a potent greenhouse gas) is not well documented. In this experiment, we monitored N2O emissions from grassland after spreading of dairy cattle slurry via splashplate (CSS) against the trailing hose applications of the slurry (CST), acidified cattle slurry (AcCS; pH 6.5), anaerobic digestate (ADi), acidified digestate (AcDi; pH 6.5), and unamended slurry control (Ctrl). The experiment was conducted in the summer and autumn seasons spreading 33 t/ha slurry in separate but adjacent fields. N2O emissions were monitored for a year after slurry spreading. N2O emissions from CSS, AcCS and AcDi were comparable in the summer application. CST had relatively higher emissions (16.6 ±2.4 g N2O-N/ha) than CSS (11.9 ±1.9 g N2O-N/ha). Emission from CST was 63% higher than ADi. In autumn application, emissions were in the order of AcDi>AcCS >ADi>CST> CSS. Statistically, emissions from AcDi (35.5 ± 4.8 g N2O-N/ha) and AcCS (28.8 ±7.3 g N2O-N/ha) were similar. ADi produced significantly higher emissions than CSS. The emissions from CSS and CST were not different in both seasons. This study suggests that N2O emissions, following slurry or digestate application, are dependent on environmental variables, often driven by seasonal fluctuations in weather patterns. Acidification of slurry triggers N2O emissions in the autumn. Based on the volume of slurry application, without considering nitrogen content, two year's average emission data indicates that cattle slurry has reduced N2O emissions compared to acidified slurry and digestate, and the application techniques do not influence the emissions in poorly drained soil.

Funded by: Department of Agriculture, Food and the Marine (DAFM) and Department of Agriculture, Environment and the Rural Affairs (DAERA)

Impacts of ground preparation on soil carbon in woodland afforestation and reforestation

By Luci Corbett, Elena Vanguelova, Kris Sales, Victoria Stokes, Tim Randle

Forest Research

Soil disturbance caused by ground preparation is well known to result in soil carbon loss by aerating the soil and allowing oxidation, decomposition and leaching. This can reduce expected carbon sequestration by woodlands, with previous models estimating that it may take many years or even up to a full forest rotation of forest growth and litter accumulation to compensate for initial losses depending on soil type and land use change.

Organo-mineral soils represent a significant portion of available tree planting area in the U.K., are carbon rich and vulnerable to degradation of carbon stocks, so long term impacts have been assessed on typical peaty gley soils. Above ground and soil carbon stocks were evaluated from 3 different intensity ground preparation methods (ploughing, trench mounding and ripping) against a control of no cultivation, from a well replicated long term experiment reforested in 1980. The findings show that ripping caused more soil carbon loss than expected, and both the ripping and ploughing treatments are still affecting soil carbon stock after 40 years. However, the accumulation of litter and fermentation layers as well as better tree growth in cultivated plots have resulted in marginal differences between overall forest carbon balance (above and below ground).

Short term impacts, by measuring carbon dioxide flux at a natural colonisation site on mineral soil in the year following low intensity ground preparation treatments, have shown increased soil respiration.

This research provides valuable empirical evidence of soil carbon changes from different intensity ground preparation techniques to support field guidance to minimise forestry ground preparation, better quantification of resulting carbon balance between above and belowground, and data to improve modelling in GHG inventories.

Key words: Soil carbon, ground preparation, woodland, tree planting, long term experiment, land use change carbon sequestration, soil respiration, organo-mineral, mineral

Funded by: UK Government through Defra's Nature for Climate Fund programme

Soil Carbon Stocks and Sequestration in Northern Irish Grasslands

By Selva Dhandapani, Alex Higgins, and Rachel Cassidy

It is estimated that globally grasslands store 236 giga tons of carbon (C) in soil belowground, and 7 giga tons of C in aboveground biomass, playing an important role in global climate change mitigation. In Northern Ireland (NI) grasslands form ~95% of the farmland cover. As part of Soil Nutrient Health Scheme (SNHS) project, we are sampling ~700,000 farms, covering almost all of NI, where nutrient availability, bulk density and organic matter content (loss on ignition) are measured. We selected a subset of 250 grasslands, representing wider active grassland management practices across NI, and are measuring soil C stocks up to 30 cm depth, extending to 1 m depth later this year, sampling both within the farm and nearby hedgerows. These selected 250 sites were also used for country wide soil survey projects in 2004, containing data on C content and bulk density for surface soil layers. We have completed 30 cm depth sampling for the majority of the 250 sites, and deeper 1 m sampling is starting in November 2024.

Our preliminary results show significant increase in C ($p=0.029$) and nitrogen (N) ($p=0.026$) content from 2004 to 2024, indicating C sequestration in NI farms over the last two decades. C and N content in hedgerow soils were greater ($p=0.004$) than nearby farm soils. We are carrying out radio C dating & measuring lability of C to estimate new C accumulation in these farms. Our results show strong correlation between total C content and organic matter content ($R2=0.91$). Thus, using organic matter content as a proxy for C and the data acquired from wider SNHS Project, we aim to calculate surface C stocks for all of NI farms. We are further using modelling approaches to identify ideal management practices for C sequestration and estimate soil C sequestration potential of NI grasslands.

Funded by: Department of Agriculture, Environment and Rural Affairs (DAERA)

The impact the Enhanced Rock Weathering (Crushed basalt) has on Soil Hydrology.

By Tanya Trott

Swansea University

Rock weathering, as well as many other soil processes related to organic and inorganic soil C dynamics, strongly depends on water availability (Hartmann, et al., 2013). The presence and movement of water stimulate the chemical weathering of basalt rock, and equally, it can be assumed that basalt dust requires soil water for the efficient sequestration of C (de Oliveira Garcia et al., 2020; Swoboda et al., 2022). Although water availability is the key parameter required for the process of ERW and associated C sequestration, none of the current studies to our knowledge have investigated the effect of soil hydrology on ERW nor the effect of basalt dust addition on soil hydraulic properties. Only a few studies so far have addressed the effects of basalt dust addition on soil physics (de Oliveira Garcia et al., 2020).

This study aims to evaluate the impact that ERW amendment of crushed basalt rock has on the soil physical properties of texture, bulk density and porosity and the subsequent impact this has on soil hydrology and CO2 efflux. Sampling has been conducted at large-scale field C sequestration project, The Carbon Community, Wales. The Carbon Community is a ground-breaking field trial to increase C sequestration in trees and soil. It uses an afforestation approach combined with two-nature-based solutions, soil microbiome inoculation and basalt addition.

The sampling method includes taking intact samples, as well as, collecting soil for laboratory experiments under controlled conditions. Samples are processed in the laboratory to understand impact on texture, bulk density, organic matter content, pH and porosity and how these impact subsequent impact soil water retention and CO2 efflux. This methodology combined with geophysics, both in laboratory and field, allows for measurements to be upscaled to field level observations without the need for extensive sampling.

Assessing Peatland Emissions of Nitrous Oxide (ASPEN)

By Wenxuan Shi

Teagasc

Peatland is an important storage of carbon (C) and nitrogen (N) on the earth surface. They have played a vital role in regulating the global climate through their capacity for C and N sequestration. Human activities including peatland drainage, burning, and conversion for agriculture transform peatlands from C sinks into greenhouse gas (GHG) sources. In Ireland, approximately 20% of the land area is peatland, over 95% of them have been degraded through anthropogenic activities. To assess the impact of peatland management on GHG emission, this study utilised the LICOR auto chamber and smart chamber coupled with state-of-the-art portable gas analysers to determine the GHG emissions from grass-based agricultural peatland in Ireland. The site-specific characteristics that drive GHG production and can act as proxies for emissions (water table height and nutrient status) were also explored. Refined emission factors (EFs) were developed for N amendments applied in both drained and rewetted peatland. N amendments including mineral N fertiliser, cattle urine and sheep urine were applied to simulate real agricultural activities on peatland. The field work is still running and the results will be collected and analysed late this year. The outputs of this work will directly contribute to the Ireland National Inventory Report and provide insight for climate mitigation and peatland rehabilitation activities.

Keywords: peatland; GHG emissions; agriculture; emission factor

Funded by: EPA

Soil For Net Zero:

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Production and modification of biochar for soil amendment to support net zero carbon goals

By Adam El-Aradi[1], *Daniel J. Nowakowski[1,*], David J. Webb[2] and Tala Kasim[3]*

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Biochar is a highly carbon-rich substance created through the pyrolysis of biomass. This innovative material has garnered considerable attention for its potential to mitigate climate change and enhance soil health. Biochar stabilises organic carbon within the soil by effectively sequestering carbon, significantly reducing atmospheric CO_2 levels. In addition to its role in carbon management, biochar significantly increases agricultural productivity. It improves the soil's ability to retain nutrients, ensuring that essential elements remain available to plants. Furthermore, biochar increases the soil's water-holding capacity, allowing for better hydration in dry conditions. It also helps to lower pH levels, which reduces soil acidity. These combined benefits make biochar valuable for sustainable farming and environmental conservation.

The physicochemical properties of biochar vary greatly depending on factors such as feedstock moisture and biochemical composition, and pyrolysis conditions (e.g., temperature and residence time). Understanding the relationship between feedstock and biochar characteristics is crucial for producing biochar with specific properties suitable for targeted soil applications.

This study reports on the preliminary physicochemical characterisation of biochar samples derived from 15 different lignocellulosic biomass species, processed under various pyrolysis conditions (250-700 °C) using gram-scale and micro-scale (Py-GC-MS) pyrolysis systems. A set of key parameters such as H/C, O/C, and N/C atomic ratios, surface functional groups, ash content, thermal stability, and porosity/surface area were evaluated to assess the suitability of biochar for soil amendment, remediation, and carbon sequestration. Ultimately, this research (in the next steps of this ongoing project) aims to further biochar modification/engineering to support its application as an effective soil improver, simultaneously meeting environmental standards of a market product (according to national and international standards - IBI Biochar Standards, European Biochar Certificate or Biochar Quality Mandate).

Keywords: biochar; biomass pyrolysis; carbon sequestration; soil amendment.

Funded by: ESRC Doctoral Training Partnership (EPS – Aston University)

A preliminary investigation into the reliability of soil carbon analytical techniques

By Adrian Crew, AJ Barwe, and Fatai Ayanda

University of the West of England

The estimation of soil carbon is essential to land management recommendations and policy realisation and climate change abatement. The measurement of soil carbon relies on new and established techniques that are of uncertain reliability but nevertheless provide the basis for carbon-related farming subsidies. We conducted a series of simple experiments to examine the recovery rates of spiked materials of two major standard techniques: loss-on-ignition (LOI) and combustion catalytic oxidation with NDIR detection via a TOC Analyser. Carbon was removed from samples of standard loamy clay soil, vermiculite and horticultural sand, which were subsequently spiked with naturally occurring organic compounds with different structural properties; glucose, stearic acid, glycine, humic acid and cellulose. These compounds were added to the solid substrates at concentrations of 1-6% carbon (w/w). The recoveries of these compounds demonstrated that both techniques revealed significant errors in estimating the percentage carbon (%C) of the spiked material. LOI generally overestimated %C from glycine and glucose added to all materials and from all added compounds added to vermiculite. The extent of the overestimation was inconsistent and between 125% and 1400%. TOC overestimated %C in more specific circumstances: humic acid in loamy clay soil and sand, glucose in sand, and stearic acid in loamy clay soil and vermiculite. However, the extent of the overestimation by TOC was more limited than LOI at a maximum of 250% at low concentrations and generally within 150%. The TOC tended to underestimate compounds in the vermiculite except stearic acid, contrary to the results from LOI, which also underestimated %C from the more complex organic compounds in the loamy-clay soil and sand. The results demonstrate the urgent need to evaluate the methods used for soil carbon analysis for reliability and accuracy to inform effective land management and carbon estimations.

Keywords: soil carbon, loss-on-ignition, TOC, methodology.

Link to Poster

Sow. Hoe. Grow.

By Bukunmi Oyewole

"Sow. Hoe. Grow" is a photo series documenting the home gardening journey of Mr. Seun Opadare in Ibadan, Nigeria. Inspired by Herbert Spencer's belief in the transformative power of action, this series captures Mr. Opadare's dedicated efforts to create a home garden. Fueled by research and a passion for sustainability, he shares insights on how home gardening shortens the food supply chain, benefits the environment, and serves as a response to the challenges of climate change. Through this project, I aim to inspire people to embrace home gardening as a practical solution for a healthier planet. And I would love to make a presentation of my images which can be found in this link: https://drive.google.com/drive/folders/1xC06f4StjJ1Lu9S9kBgTlhFvMB5uu9s0?usp=sharing

Link to Poster

Remote Measurement of Soil Organic Carbon: Unlocking Soil Carbon Monitoring in the Global South

By Christopher Lakey

Downforce Technologies

It is estimated that soils have lost 8% of their carbon content since human farming began. Around the world, agricultural soils are highly degraded and are a significant source of greenhouse gas emissions.

Soil carbon content is a good proxy for soil health. Healthy soils are more resilient to climate shocks and achieve high yield to input ratios, as well as making the soil a net carbon sink. From a climate change perspective as well as a food security perspective, there is growing interest in rebuilding soil carbon stocks, requiring effective measurement and monitoring.

For much of the global south, pressures from input costs are greater and risks of food insecurity more acute: issues that raising soil carbon levels can address. Accurate soil carbon measurements could also give farmers access to carbon markets as valuable alternative income streams, or to green loans.

Traditionally, measuring soil carbon relies on in-situ sampling. This is expensive and labour intensive and so encourages low density sampling and infrequent repeat measurements. In the global south, equipment for in-situ sampling is often not available, and costs are prohibitive. However, remote measurement can provide a solution.

We have developed a methodology for remote measurement of soil carbon stocks. By combining remote data from satellite observations with data "from the ground", it is possible to measure soil carbon stocks at scale and record change in stock levels over time, providing a spatially and temporally explicit view of soil carbons stocks. This approach has several advantages over conventional soil carbon assessment, being low cost, not requiring access to the land being assessed, and applicable globally.

The technology is currently being used for wide-scale carbon mapping, and for carbon monitoring projects in many countries including the UK and Kenya.

Keywords: Soil Carbon, Remote Measurement, Global South, Ecosystem Services, GHG Removals

A biogeochemical perspective on the trajectory of change of microbial processes during peatland restoration

By Claire McNamee, Ashish Malik, and William Pallier

University of Aberdeen

Peatlands are vital carbon sinks, but large-scale degradation has affected their ability to sequester carbon. Peatland ecosystem health is being restored to reverse carbon losses and potentially even increase carbon accrual. However, it is not clear how long it takes for a restored system to turn from a carbon source into a carbon sink. We used a space-for-time substitution approach to study peatland sites in proximity that were at different stages of restoration: 1, 3 and 6 years since restoration began. These sites were compared with a damaged and a benchmark near-natural system. Restoration was performed primarily through blocking existing drains to raise the water table. Indicators of peat health, including moisture content and oxygen levels across various depths, revealed expected patterns of increased moisture and decreased oxygen along the restoration gradient. We investigated greenhouse gas emissions from each site and found that restoration age significantly influenced these emissions, with more restored sites showing reduced CO2 and CH4 emissions. A metagenomic analysis of the top 10 cm of peat revealed shifts in microbial communities and functional gene abundance, reflecting a correlation between microbial diversity and peatland health. This shift indicates that microbial community structure is closely tied to the success of restoration efforts, microbial composition after 6 years of restoration resembled that of the near-natural system. Vegetation surveys provided further insights into the botanical changes accompanying restoration efforts, whereas chemical characterization of the peat conducted using FT-ICR-MS and FTIR offered deeper insights into the chemical transformations occurring during degradation and restoration. Our findings underscore the importance of a multidisciplinary approach in assessing peatland restoration. By integrating botanical, geochemical, and microbial analyses, this study provides a comprehensive understanding of the trajectories of change in restored peatlands and their implications for the ecosystem carbon budget and achieving net-zero carbon emissions.

Funders: NERC, SUPER DTP

Reducing NO3 leaching, NH3 and N2O emissions in babyleaf spinach production systems for via reduced fertiliser input, nitrogen cycle inhibitors and high carbon organic amendments.

By Ellie Barbrook, Liz Shaw, and Tom Sizmur

University of Reading

Extensive work has already been conducted on optimal N cycle inhibitors (NCI) and synthetic N fertiliser use in cereal systems. However, the short growth cycle (4-6 weeks) and multiple within-season harvests for babyleaf spinach, has implications for dynamics of soil N availability, potentially revealing novel relationships between indices of plant- available N. This work aims to apply strategies for minimising N loss from soil in cereal systems to babyleaf spinach crops for sustainable production.

Chemical, physical and biological methods were compared to quantify actual N supply of 15 UK soils (varied past fertiliser regimes (CAN, Nitram, FYM, spent mushroom compost)) whilst growing spinach over four weeks. This work aimed to improve the way that fertiliser rates are recommended, to reduce N loss from soils whilst retaining yields. Taking the best of these methods forward, they were used in field trials to quantify the amount of plant available N before fertilization.

The trials were established to examine the interactive effects of N fertiliser application rate and nitrification inhibitor (nitrapyrin). Nitrogen cycle inhibitors (NCIs) are an effective solution to reducing NO3 leaching and gaseous emissions from soil, without reducing crop yields. Together this new approach to synthetic N fertiliser inputs for babyleaf spinach has allowed a 27- 37% reduction in fertiliser application rates whilst maintaining the same yields.

The effect of high carbon organic amendments (HCOA) (straw (at two rates), glycerol and a combination of both) and nitrapyrin on post-harvest N losses from soil was assessed in a pot experiment over 7 weeks. NO3 leaching, NH3 and N2O emissions were measured, mirroring the previous field trials. NO3 leaching was reduced when HCOAs were applied. Indicating a low cost solution for growers to implement a sustainable practises to minimise N loss from soil during the production phase and post-harvest.

Funders: BBSRC, Waitrose CTP

NCS: Investigating the role of legumes in Nitrogen Climate-Smart agriculture

By Emily Guest

Cranfield University

Legumes are well-known for their symbiotic associations with nitrogen-fixing bacteria, reducing the requirement for synthetic nitrogen fertilisers in both leguminous crops and subsequent rotations. Despite their benefits, legumes remain underutilised in the UK due to perceived yield instability, resulting unprofitability and uncertainty in their ability to provide adequate feed nutrition. To address these issues, the NCS 'Nitrogen Climate Smart' project was launched as a four-year research initiative aiming to increase pulse and legume cropping in UK arable rotations from the current 5% to the recommended 20%. This shift could lead to a significant reduction in greenhouse gas (GHG) emissions due to a reduction in synthetic nitrogen fertiliser use and the replacement of imported soya meal with home-grown legumes, driving an estimated decrease of 1.5 Mt CO2 equivalent per annum, representing 54% of the maximum potential for UK agriculture. This presentation will discuss the rationale and initial findings from a controlled glasshouse experiment within the NCS project, using large soil modules to explore plant-soil-atmosphere interactions in legume-based crop rotations at greater detail than possible in a field-scale experiment. Early results will address whether a legume-based rotation enhances nitrogen use efficiency and soil carbon storage, ultimately lowering GHG emissions. As a closed system, the nitrogen balance can be determined, accounting for loses in the soil profile through the use of soil nitrate sensors and measuring direct GHG emissions at a high frequency throughout the growing season. From sensor-based approaches, insights will be provided on how to boost and make the most of biologically fixed nitrogen and quantify temporal and spatial nitrate availability, and how this changes with soil moisture and legume yield. This research aims to provide actionable evidence for optimising legume-based crop rotations, boosting the effectiveness of nitrogen management and contributing to significant GHG emission reductions and more sustainable agricultural practices.

Funders: Defra's Farming Innovation Programme, delivered by Innovate UK.

Link to Poster

Reviewing the reuse of excavated peat on windfarm development sites in Scotland

By Felicity Crotty, Kate Schofield**,** Matt Barker, and Lea Herold

Ricardo - Agriculture and Land team

The UK is committed to reaching net-zero by 2050, through GHG emission reductions and increasing carbon sequestration. Switching from fossil fuels to renewable energy is one of the main tools to achieve this. Renewable energy technologies change the landscape; for wind turbines, most consider the aesthetics, as wind farms are highly visible. However, there may be a larger impact related to the underlying construction, particularly when built on peatlands. Peatland habitat and their associated carbon-rich soils (peat and peaty soils) are the largest terrestrial carbon source and vital for GHG mitigation, as active peatland can sequester new carbon mitigating the effects of climate change. However, when peat is drained, exposed and degraded it is susceptible to biochemical oxidation and desiccation, leading to a loss of carbon and increased GHG emissions. Peatlands cover around 25% of Scotland and can have suitable environmental conditions for onshore wind farms due to the exposed environments they are located in. Currently, 48% of wind farms in Scotland have already been built on carbon-rich soils with this number likely to increase. The main activities of wind farm development includes track construction, quarried aggregate extraction and turbine foundation excavation, site compounds and electricity sub-stations, large-scale disturbance can produce large volume of excavated peat, affect wider peat stability, its integrity and the hydrology of the surrounding habitat. This project reviews the range of on- and off-site practices for the use of excavated peat material in windfarm development sites in Scotland, and by assessing the environmental impact of each, informs best practice guidance currently under development. We seek to engage the scientific community at this early stage of the project to enable us to develop a hierarchy of reuse that preserves peat and its ecosystem functions as well as reducing the loss of carbon.

Funded by: Climate X Change

Woodland Creation Scheme in the Yorkshire Dales focuses tree planting on lower carbon soils

By Francesca Darvill

University of Leeds

Extensive tree planting and woodland creation is being promoted for urgently needed climate change mitigation. New studies evidence tree-planting in the UK uplands may cause soil carbon loss, resulting in no net gain of ecosystem carbon over decadal timescales. Space-for-time approaches are commonly used to investigate difference in soil carbon after native woodland creation (NWC) as baseline data is commonly missing. However, the uplands are typically formed of mosaics of ecologically diverse, semi-natural habitats and this complexity may not be well represented in our long-term monitoring approaches to accurately measure change in terrestrial soil carbon.

We hypothesis that NWC schemes preferentially target lower carbon soils, and space-for-time approaches are not accounting for this factor in measured carbon loss. We assessed topsoil carbon (0-15cm depth) within two tree-planting densities; high-density (estimated 2940 stems/ha) and low-density (estimated 860 stems/ha), used in a new NWC scheme in the Yorkshire Dales, UK, 8 to 13 months after planting. Each of the five replicate 10x10m plots within the two density treatments were geographically paired with an unplanted control plot based on aspect, elevation, and hill-slope gradient. Our aim was two-fold. Firstly, to determine if the NWC had successfully selected lower carbon soils for tree planting. Secondly, to assess the reliability of space-for-time monitoring approaches when working in the uplands.

We found the average topsoil carbon stock in the high-density tree planting plots (80.4 ± 3.8 t C/ha) to be significantly lower than in the unplanted plots (100.4 ± 4.6 t C/ha) and the low-density plots (90.8 ± 3.3 t C/ha). Our results so far suggest that this NWC scheme preferentially avoided higher carbon soils. Furthermore, they highlight potential errors associated with using the space-for-time experimental approach when attempting to estimate the carbon uptake or loss in the uplands.

Key words: Restoration, Woodland Creation, Soil Carbon

Funded by: Peter Sowerby Foundation

Urban Soil Quality & Carbon: Post Construction Green Space Soil

By Jennifer Carfrae, and Yecheng Tan

SRUC

Climate change poses one of the greatest challenges of our time, with rising atmospheric CO_2 levels driving significant environmental impacts. Effective carbon management strategies are essential for mitigating these effects, and soils represent a crucial component of the global carbon cycle. Construction soils, often disturbed and compacted, present unique challenges and opportunities for carbon storage. Urban areas, especially those undergoing extensive construction activities, hold substantial potential for carbon sequestration. Despite this potential, the impact of construction on SOC and effective management practices to enhance carbon sequestration in urban soils remain under-researched.

Construction activities often lead to soil compaction, loss of topsoil, and reduced organic matter, which can significantly diminish the soil's capacity to sequester carbon. Furthermore, the effectiveness of various soil management practices in mitigating these impacts and enhancing SOC in construction soils remains underexplored by the industry. This research aims to bridge these knowledge gaps by providing real world data on SOC levels in construction soils over time following vegetating to evaluate changes in soil health and SOC and to help promote sustainable urban soil practices post construction.

A mixed-methods approach was employed, integrating both qualitative and quantitative data collection and analysis via literature review, stakeholder interviews and soil sampling. Interviews were undertaken from a construction perspective and from a landscape architects perspective. These were followed by soil analysis from a case study site outside Edinburgh which is a post construction green space providing comparison of recent grass seed spreading (within 2 weeks), 5 year old deciduous woodland, with a extant mature deciduous woodland at the same location. The soil on the case study green space was top soil stored on the active construction site and treated prior to laying to remove stones and gravel.

Key words: Carbon Sequestration Potential, Soil Carbon, Soil Quality, Urban / Construction Soil, Urban Greenspace.

Floods and droughts - are soils more significant drivers than increasing temperatures?

By John Quinton[2], Karl Auerswald[1], Juergen Geist[1], Peter Fiener[3]

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The frequency of floods, droughts, and heatwaves is increasing globally. This is often attributed to CO2-driven climate change. However, at the global scale, CO2-driven climate change neither reduces precipitation nor adequately explains droughts despite the modest increase in evapotranspiration due to temperature rise. We argue that soil and land management, particularly soil sealing, compaction, and drainage, are likely more significant for water losses by runoff leading to flooding and water scarcity. However, the importance of these processes is poorly addressed in hydrological modeling as models rarely reflect lateral fluxes in the atmosphere, on the soil surface, and in the soil. Land use is only considered in coarse categories, and neighborhood effects and feedback mechanisms are neglected.

However, even if models fail and if we cannot create landscape experiments, there is sufficient evidence that soil management and land use an important part of the problem and of the solution to mitigate floods, droughts, and heatwaves. Addressing soil management and land-use changes is imperative as they will persist even if we manage to reach zero net CO2 emissions, making the world more vulnerable.

Keywords : Floods, Droughts, climate change, soils, soil management, land use

Agroforestry prevents nitrogen spreading from livestock housing

By Kaisa Ilmari, and Elena Vanguelova

Forest Research

Reducing emissions and pollution from agriculture is a key challenge in creating more sustainable food production systems as well as reaching air pollution abatement targets. One of the priorities set out in the UK government's Clean Air Strategy 2019 is reducing ammonia emissions which nearly 90% of in the UK originate from agriculture, primarily beef, dairy and poultry farming. Many ecosystems exceed their critical nitrogen load, which can cause detrimental effects on the environment, including eutrophication and biodiversity loss. However, studies have shown that mature woodlands close to poultry farms are able to scavenge atmospheric ammonia through their foliage and store it in their canopy and the soil. A form of agroforestry, where trees are planted immediately outside livestock housing in a shelterbelt design, could therefore prove a powerful ammonia mitigation solution for farmers in addition to providing wider benefits such as carbon sequestration and increase biodiversity.

This study provides new evidence on the effect of tree shelterbelts on soil properties at five poultry and dairy farms in Cumbria, UK. A mix of native broadleaves with some coniferous and fast-growing hybrid species were planted in 2009-2010 in the range of egg-laying hens. Aboveground measurements of atmospheric ammonia and tree mensuration, followed by soil sampling was carried out 10-14 years later along transects from the housing, a point source of ammonia emission, up to 200 meters inside the shelterbelt. In the majority of the farms, available nitrogen (specifically nitrate) in the soil declined with distance from the housing, likely due to increased nitrification activity due to excess nitrogen near the farms. This is supported by the increased tree nitrogen uptake and tree growth near the housing. Additionally, soil nitrous oxide flux, a potent greenhouse gas, was found to be higher on average near the housing likely due to increased nitrification. Excess nitrogen can also cause acidification in the soil, but this was found in only one farm with an increasing pH trend with distance. In the rest of the farms, pH decreased with distance. An additional study at one of the farms found that high nitrogen and low pH altered the bacterial and fungal community composition, key indication for understanding the wider impacts on ecosystem biodiversity and functioning.

In conclusion, the results from this study shows that nitrogen is significantly higher in trees and soil immediately adjacent to the poultry housing and reduces with distance, supporting the hypothesis that trees are a viable mitigation option for farmers and land managers looking to reduce their ammonia load to the surrounding environment. With the co-benefits of improved animal welfare, carbon storage and potentially an additional income, agroforestry is an important tool in securing the future of farming.

Key words: Agroforestry, shelterbelts, ammonia, available nitrogen, soil greenhouse gases

Link to Poster

The importance of accurately assessing upland soil carbon stocks in progressing towards sustainable production on livestock farms

By Laura Giles

Lancaster University

There is a growing demand in the UK hospitality sector for environmentally-sensitive, carbon-efficient meat products, yet, no such products currently exist at scale. Concurrently, livestock farms are increasingly challenged to reduce greenhouse gas emissions and change from intensive food production to adopt more environmentally-sensitive farming practices.

Whilst it is generally understood that much of our agricultural soil has capacity to build carbon stocks and potentially mitigate on-farm carbon emissions, for many upland or marginal farms, comprehension of current and potential soil carbon stocks is lacking. Verifying changes in carbon stocks in these environments is challenging given the difficult terrain and high degree of soil heterogeneity. Yet, understanding the impact of changes in upland livestock management on soil carbon is critical to ensure future land management scenarios are environmentally positive and can sustain food production.

We aim to address this knowledge gap through pedogenically-based on-farm sampling and soil carbon modelling. These data will subsequently be fed into environmental accounting models to generate environmental and financial analyses of current and future farming scenarios, offering information that can help farmers and supply chains offer more financially viable and environmentally positive products.

Working with business partners, we have established a baseline of soil carbon stocks, conducted via stratified random sampling of the top 0 – 30cm soil on three upland livestock farms in Cumbria. Samples were taken at a rate of 1 per 2 hectares; ≥5 metres apart; assessed for bulk density (corrected for coarse fragments ≥2mm) and C/N concentration (by dry combustion). Using these data, and by adapting a carbon model (N14CP) for pasture-based systems, we will investigate how changes in livestock-farming practices may influence carbon stocks on upland farms.

Here we report on the soil survey and offer it as a methodology for assessing carbon stocks in heterogenous grazed landscapes.

Funded by: Innovate UK; Lake District Farmers

Legume-based intercropping: A pathway to reduced N2O emissions from agriculture?

By Luke Harrold

SRUC (Scotland's Rural College)

Intercropping is a farming practice which involves growing two or more crops together for a period of time with the aim of reducing inputs while maintaining or improving yields. The practice could help deliver the sustainable intensification of agriculture. An intercropping experiment was conducted in Aberdeen as part of a multi-disciplinary and multi-actor meta-experiment involving 27 participants from 15 countries (three continents) aiming to exploit the benefits of intercropping to design and manage productive, diversified, resilient, profitable, environmentally friendly cropping systems. Our focus was on soil health and greenhouse gas (GHG) emissions (N20) as well as yield performance and yield stability of intercrops vs. sole crops.

A trial was set up comparing pea-only, barley-only and intercropped barley-pea with three levels of nitrogen fertilisation, zero, half and full standard rate. Preliminary results indicate that there is no significant difference between the N2O emission from sole-barley with full rate of N-fertiliser and the intercrop with half-rate of N-fertiliser at least in the early growth stages. The results of this experiment will not only help understand the practice locally but feed into an international project to gain a deeper understanding of the factors which influence yield outcomes.

Funded by: HORIZON-CL6-2022-BIODIV-01

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Can paludiculture work commercially as part of an intensive vegetable production system?

By Megan Hudson, Islam Abdel-Aziz, and Brenda D'Achunha

Fenland SOIL Ltd.

Lowland Agricultural Peatlands are a major barrier to UK agriculture meeting its Net Zero by 2040 target. One potential solution on deep drained lowland agricultural peat soils is to transition to paludiculture, a system of agriculture for the profitable production of crops tolerant of wetter conditions and water tables of 10 to 30cm to halt emissions and maintain some element of production. However, currently little is known about the potential for different crops to perform commercially within such systems and no evidence as to the impact it will have on the ability of farm businesses to maintain viability.

Under the Paludiculture Exploration Fund, the project set out to explore the commercial viability of paludiculture within an intensive vegetable farming system by carrying out a field scale trial. A farming partner was subcontracted to carry out the operational activities on farm, with independent specialists supporting the monitoring of the site.

The trial took place on a 3ha field on an intensive vegetable farm near Southery in Norfolk, the following crops were selected for the trial:

- Celery – on the paludiculture crops list and one of the farms specialty crops.
- Chinese Leaf Cabbage – a specialist crop on the host farm, with very shallow rooting and short growing cycles.
- Miscanthus – also on the list of potential crops for paludiculture as a potential replacement biomass crop for anaerobic digestion

The project team managed to grow both salad crops using the same management practices as our conventionally grown control site, including mechanical weeding, pesticide and nutrition sprays. Following harvest of our salad crop trials at our paludiculture site in August, the project aims to share our experiences, key learnings and some early trial results as well as our ambitions for further work following this year's trial work.

Funded by: Natural England

Could Food Waste Fermentation Store Carbon in Soils?

By Samantha Kehoe, and Tom Sizmur

University of Reading

"Food waste is a major source of greenhouse gas emissions. Composting of organic waste results in the loss of approximately 40% of the carbon in the feedstock, primarily as CO2 (Ye et al., 2023). This means that only ~60% of the carbon in food waste is returned to the soil as compost. Food waste management methods that can increase the proportion of carbon returned to soil have the potential to contribute to both soil health and carbon storage.

One alternative waste management method that may achieve these goals is lactic acid fermentation of food waste, also known as 'Bokashi'. This method uses microbial inoculants in an anaerobic environment to partially break down and stabilize organic wastes at a low pH. The resulting fermented material can be used as a soil amendment which, theoretically, retains a much higher proportion of the carbon contained in the feedstock. Bokashi is currently used successfully at small scales, but little is known about the greenhouse gas emissions during food waste fermentation, or on the potential for the buried material to store carbon in soil.

We investigated the fermentation process and carbon retention in fermented products through lab scale incubations using a model food waste (cabbage and potato). We found that 88-98% of the carbon in the original food waste was retained in the solid fermented material. Carbon emitted as CO2 or CH4 accounted for <0.02%, with 0.5-2% drained as liquid leachate.

These initial findings highlight the potential for Bokashi fermentation to reduce emissions of CO2 and CH4 in food waste processing and preserve carbon in a form suitable for soil application. Further experiments will investigate emissions in more realistic conditions and track gaseous emissions from soil after application of fermented materials.

Keywords: Food waste, Bokashi, soil amendments, carbon, waste valorisation, fermentation, GHG mitigation"

Funded by: BBSRC Foodbiosystems DTP, Agriton Ltd.

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Towards Net Zero in potato systems: How does cultivation intensity impact CO2-C emissions and soil structure following potato establishment?

By Segun Oladele, Iain Gould, and Sandra Varga

University of Lincoln

High-intensity cultivation practices exacerbate soil carbon losses and CO2 emissions, degrading soil structure and health. To reduce these negative effects, this study explored alternative cultivation methods as part of a broader regenerative farming project for potato systems in the UK. In 2023, an on-farm study was conducted on irrigated potato fields contrasting in soil textures across three UK locations: Bardney-England (sandy loam), Angus-Scotland (sandy loam), and Langrick-England (silt loam). We evaluated high, medium, and reduced cultivation intensities impacts on CO2 emissions and soil structure during the potato growing season. CO2-C emissions were measured in situ using an IRGA sensor, along with soil moisture and temperature at bi-weekly intervals for up to 18 sampling dates. Soil structure indicators (shear strength, aggregate stability, and bulk density) were assessed at 0–30 cm depth during seed bed establishment, mid-season, and harvest as proxies of soil health. Findings showed that cumulative CO2-C emissions were similar (non-significant) across cultivation intensities and soil texture/locations (Bardney: 106.98-109.50 g CO2 m-2 hr-1 ±5.89-11.4; Angus: 55.79- 62.62 g CO2 m-2 hr-1 ±2.09-9.28; Langrick: 59.04-69.09 g CO2 m-2 hr-1 ±5.49-9.13). Further, reduced cultivation significantly improved soil structure by decreasing bulk density at Angus and Bardney (sandy loam), increased soil shear strength at Angus and increased aggregate stability by 58% only at Langrick post-establishment compared to high cultivation intensity. Remarkably, high cultivation intensity increased aggregate stability significantly by 79% prior to harvest at Angus. Overall, cultivation intensities (high, medium, or reduced) had no significant impact on CO2 emissions during the potato growing season. However, reduced, and medium cultivation intensity generally protected and improved soil structure, suggesting potential for adoption towards sustainable potato farming practices.

Keywords: Soil carbon emissions; Tillage intensity; Sustainable agriculture; Soil structure

Funded by: UKRI-Innovate UK

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Real-time assessment and measurement of soil carbon in agricultural land of Gloucestershire at a farm-scale

By Wing Kwan Pauline Ng, Adrian Crew, and Matt Bell

Hartpury University and University of the West of England

Previous research promoted carbon assessment and flow of human and natural capital to remediate atmospheric carbon emissions on farms. However, differences among types of agricultural land are often not included as part of measurement methods. This study collected soil and plant measurements for 530 field samples in Spring 2023 to compare levels of soil organic carbon (SOC) among different agricultural land uses across Hartpury and Cirencester, Gloucestershire using real-time near-infrared spectroscopy (NIRS) analysis. SOC was expressed as g/kg, t/ha and ratio to soil clay content. A higher percentage of permanent grass and woodland areas were classified as having good and satisfactory SOC/clay ratio compared to arable and temporary ley fields. Permanent and woodland areas also had higher mean SOC (g/kg), total nitrogen (g/kg), soil , carbon (t C/ha), nitrogen (t N/ha) and soil moisture (%). Although arable and temporary ley fields were more productive with a greater herbage height (7.1 cm and 6.3 cm respectively) and biomass cover (7073 kg FW/ha and 6839 kg FW/ha respectively) than permanent grass fields (4.5cm and 6199 kg FW/ha), permanent grass fields still had significantly better levels of SOC, nitrogen, as well as other critical soil and plant properties such as SOC/TN ratio, TN/Clay ratio, plant fresh density (kg FM ha−1cm−1), dry density (kg DM ha−1cm−1), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF) and protein (all in g/kg DM). This study shows that NIRS can serve as a user-friendly and practical alternative for large scale measurements to monitor soil and plant properties among agricultural land uses. Further work is needed to evaluate the NIRS measurements against standard measurement approaches across a range of soil and plant type to support large scale field monitoring.

Keywords: Soil carbon, real-time, farms, sequestration, NIRS

Funded by: Hartpury, John Oldacre Trust and The Douglas Bomford Trust

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Quantification and Identification of Microplastics in English and Welsh Soils: A Study Using Nile Red Staining and Laser Direct Infrared Methods

By Aslihan Benlioglu, Davey Jones, Christopher Collins

University of Reading

Microplastic is one of the significant pollutants in the world. Although there are many studies about microplastics in the aquatic environment, there are fewer studies investigating microplastic pollution in the terrestrial environment. Microplastics are defined as plastic particles that are smaller than 5 mm and can be derived from primary or secondary sources. Primary microplastics may come from personal care products, fibres, and plastic pellets. Secondary microplastics occur from the degradation or abrasion of plastic sheets or plastic products like plastic bottles.

This study quantified the amount of microplastics in 179 soil samples collected across England and Wales from rural, semi-rural, and urban soils by using a fluorescent microscope with the Nile Red staining method. The results were crosschecked with 60 of the 179 samples by using Lazer Direct Infrared (LDIR), and the number of the detected microplastics compared between two methods. Also, the type of microplastics defined by using LDIR in soil.

This research discusses the advantages and disadvantages of using Nile Red staining and LDIR methods to identify microplastics in soil.

Key words: microplastic pollution, microplastic identification, LDIR, Nile Red staining, soil pollution, microplastic counting

Funded by: Republic of Türkiye Ministry of National Education

Environmental Impact Assessment of Soils and Agricultural Land - Application of the IEMA Guidance

By Duncan Rose, and Dr Gruffydd Jones

Wardell Armstrong

The Institute of Environmental Management and Assessment (IEMA) issued their guidance document 'A New Perspective on Land and Soil in Environmental Impact Assessment' in February 2022. This document is the first published guidance on the consideration of soils and land in EIA, but it does not include a clear methodology for how such assessments should be undertaken.

We will be presenting how this guidance has been practically applied within scoping and ES chapters for EIAs. Traditionally the receptors identified for the assessment have only included Agricultural Land (ALC) and Soil Resources (damage and loss of soil resource). We will give an overview of how these have been incorporated into the assessment but also explore other soil functions that can be included within the assessment such as Soil Biodiversity and Soil Health, and Climate Change, Soil Organic Matter and Soil Organic Cabon.

The challenges of implementing this approach will be discussed and we will assess what will be required within the industry to develop the assessment methodology.

Key Words: EIA, IEMA, Soils, Soil Health, Soil Organic Matter, Soil Organic Carbon, Soil Biodiversity, Soil Function, ALC

Maximising the re-use of soil resources: delivering ecosystem services and biodiversity on major construction projects

By Jessica Potts, and Bruce Lascelles

Arcadis

Soils provide a wide range of ecosystem services and this has resulted in their overuse and exploitation, in part due to the existence of stringent waste regulation compared to non-existent legislation focused on the wide range of soil ecosystem services which come from healthy soils. As the construction industry advances towards sustainable practices, optimising soil resources to meet landscaping and biodiversity requirements has become vital, although often available soil resources may not match the intended landscaping or habitat creation uses. Using the case study of Poynton Relief Road we will explore the real-life solutions employed to enhance soil properties and promote species rich grassland planting, aligning with circular economy principles, reducing soil waste and maximising biodiversity gain.

The Poynton Relief Road project encountered significant challenges as the in-situ topsoil failed to meet the nutrient requirements needed to support the planned biodiversity-rich landscaping Using comprehensive assessments of topsoil and subsoil characteristics, in isolation and as a range of topsoil/subsoil mixes, a bespoke and balanced soil medium was created conducive to the establishment and growth of diverse plant species. This approach insured that the resulting soil matrix provided suitable growing conditions, therefore supporting the project's ecological and environmental goals.

Throughout the project, Arcadis deployed real-life management techniques, leveraging our expertise in sustainable land use, environmental stewardship and the circular economy. The outcomes supported the projects aim to minimise site waste through on-site resource optimisation and reduce the need for soil imports.

Based in post-construction monitoring, the outcome of this approach has been found to be successful, with the mixed soil matrix supporting robust plant growth and fostering a thriving species rich grassland. The project not only met but exceeded client expectations, showcasing how thoughtful soil resource management can drive sustainability in construction.

Keywords: Ecosystem Services, Biodiversity, Sustainable Construction, Soil Resources, Circular Economy

Biochar – Is biochar effective for improving soil quality in a UK context?

By John Langley-Randall, Despina Berdeni, and Anne Bhogal

ADAS

Biochar is a solid material produced through the pyrolysis of organic material in an oxygen-free environment. It has been suggested that biochar has the potential to contribute to the UK targets for net-zero greenhouse gas emissions, via carbon sequestration, when applied to agricultural soils.

A Rapid Evidence Assessment (REA) was carried out to assess the current state of knowledge regarding the impacts of biochar use on agricultural soils, including the merits and trade-offs, from studies carried out in a temperate oceanic climate, and published since 2009. The REA returned 41,500 papers, of which 208 were reviewed following screening for relevance.

Key findings from the REA indicate that a variety of feedstocks (estimated 13-25 million tonnes fresh weight annually in UK) could be used to create biochar, with wood waste (woodland thinning, brash etc.) most suitable. To date, the long-term stability of biochar has been extrapolated from short-term experiments, while modelling, based on the H:Corg ratio of biochars, is now proposed as a more promising method.

There is increasing evidence that, in some situations, biochar application can benefit soil quality especially in raising soil pH through its liming effect. Additional potential benefits include increased CEC, and structural benefits, such as reduced bulk density, but this is application rate, soil type and biochar type dependent. Crop yield benefits previously found in tropical regions have not consistently been reported in more fertile temperate soils, and higher application rates (>10 t ha-1) may lead to yield reductions. High purchase costs (£200-£600 t-1), limited fertiliser replacement value and restrictions on the quantity and type of biochar that can be spread mean that the use of biochar is not currently economical or practicable for many farmers in the UK.

Keywords: Biochar; feedstock; net zero; sequestration; soil health; bulk density; soil pH; crop yield

Funded by: Defra

UK-Wide Assessment of Organic Contaminant Residues in Agricultural Soils Following Biosolid and Manure Amendments: A Comprehensive Monitoring Study

By John Nightingale

The University of Leeds

The application of organic wastes, such as biosolids and animal manures, to agricultural soils is a common practice in the UK for enhancing soil fertility. However, this practice introduces a pathway for emerging contaminants into agro-ecosystems, potentially leading to their accumulation in soils, subsequent uptake by crops, or losses to receiving waters. This raises significant environmental and human health concerns. To address the current knowledge gap regarding the extent of organic contamination in UK soils, a comprehensive monitoring study was conducted in 2022. Twenty-two farms were sampled, yielding 472 field samples. A novel multi-residue soil extraction method was developed and validated, capable of detecting contaminants across a broad concentration range (0.1 µg/kg to 15 µg/kg, dry weight). The analysis employed advanced LC-MS/MS and HR-MS/MS techniques for both quantification and qualification of a diverse array of organic contaminants, including human pharmaceuticals (e.g., antibiotics, anticonvulsants, NSAIDs), veterinary medicines, personal care products, herbicides, pesticides, and biocides. Our findings reveal the presence of several organic contaminants across the sampled farms, including carbamazepine (0.03-44.49 µg/kg dw), clotrimazole (0.2-274 µg/kg dw), oxytetracycline (12.25-29.24 µg/kg dw), enrofloxacin (0.15-9.58 µg/kg dw), diazinon (2.96-7.19 µg/kg dw), ofloxacin (plasticizers>research chemicals>fungicides). The data indicate higher levels of contamination in soils treated with biosolids compared to those receiving conventional animal manures. These results highlight the significant impact of biosolid applications on soil pollution and underscore the nascent stage of our understanding regarding the risks associated with these practices. Given the projected increase in biosolid use as part of sustainability goals, there is an urgent need for more comprehensive risk evaluations to better assess the long-term implications of persistent chemical contaminants in soils and their potential effects on the food chain.

Funded by: UKRI

The Impact of Over Winter Cover Crops on Soil Health in Northern England

By Marta Cattin*[1], Alastair Robson[2], Alan Johnson[3], Caitlin Dolan[4]

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Current government schemes (e.g. Sustainable Farming Incentives and Countryside Stewardships) incentivise farmers to use cover crops (CC) in their arable rotation; this is because CC have the potential to improve soil structure, soil biology and reduce nutrient losses to watercourses. However, due to the temperate climate and short growing season in Northen England, farmers are still uncertain about the potential soil health benefits associated with the introduction of CC into an arable rotation. Therefore, as part of the EU LIFE WADER project, a three-year field experiment (2023-2026) was established on a sandy loam soil in Northumberland (UK), with the aim to investigate the soil health benefits of over winter CC (tillage radish) vs bare soil (control, Ctr), prior to spring barley (SB) drilling. During 2023-2024, CC biomass was analysed to investigate yield and nutrient uptake over winter and soil investigations (e.g. chemical, biological and physical) were carried out prior to and after CC termination. Preliminary results indicate CC average dry matter (DM) yield was 1.6 t/ha and average total nitrogen was 54.5 kg/ha (DM). Improved soil structure and reduced soil capping was also observed under CC than Ctr, as well as better water infiltration and earthworm number. Soil nutrient status pre-CC incorporation was also enhanced compared to Ctr. Soils under CC increased Soil Mineral Nitrogen content by +40%, microbial biomass by +18% and fungal biomass by +22% compared to Ctr. Similar trends were also observed after CC incorporation. Our research demonstrates that the use of CC in a Northern England has potential to reduce nutrient losses over winter, improve soil structure, enhance soil biology and available nitrogen compared to bare soil. The initial findings will be validated throughout the remaining two years of experiment.

Key words: cover crop, nutrient turnover, soil structure, soil health, infiltration

Funded by: EU LIFE Programme

Assessing the impacts of farm management practices on orchard soil biodiversity

By Maya Sollen-Norrlin

Canterbury Christ Church University

Microbial soil biodiversity drives the multifunctionality of soils which in turn supports the many ecosystem services that soils provide. Despite the often-negative impacts of agriculture on soil biodiversity, orchards have high potential to be sustainable agroecosystems that supports healthy soils capable of maintaining ecosystem services. In this study, apple orchards from south-east and south-west of England are used as a model system to investigate the effects of apple orchard management on soil microbial diversity, soil chemistry and soil function. 350 soil samples from 15 orchards in Kent, Sussex, and Somerset were collected during August – October in 2022 and 2023. Samples were taken at regular intervals diagonally across one plot in each orchard. eDNA was extracted from a subset of 180 samples (approx. 10 from each orchard) and amplicons of the bacterial 16S gene, the universal fungal ITS2 gene, and the Arbuscular Mycorrhizal Fungi (AMF) 18S gene was carried out to compare bacterial and fungal biodiversity between apple orchards under low and high intensity management. Preliminary results indicate that apple orchard management practices can be a driver of soil microbial community composition and diversity alongside soil physiochemical properties such as soil pH and organic matter, which have been analysed for all 350 samples. This suggests that the sustainability of apple orchards can be increased by managing orchards for more diverse soil microbiomes through sustainable practices.

Keywords: agriculture; soil biodiversity; orchard; microorganisms; fungi; bacteria; ecosystem services

Funded by: NERC Environmental Omics Facility (NEOF),Canterbury Christ Church University

Soil degradation from the Russia-Ukraine conflict: A field study

By Naomi Rintoul-Hynes, Jannette Carey, and Anastasiia Splodytel

Canterbury Christ Church University

Military activity can negatively affect soil physio-chemical properties due to catering by munitions, compaction by military traffic, and pollution from ammunition, munitions, explosives, vehicle parts and infrastructure. This could have severe consequences in Ukraine as the country relies heavily on agriculture due to their highly fertile chernozem soils. It could also impact countries that are dependent on agricultural exports from Ukraine. In a rare field study during active conflict, we collected 274 soil samples from across Ukraine, including areas experiencing the most intense conflict. Several physio-chemical indicators of soil health and over 20 contaminants were quantified.

Results demonstrate that military activity has been detrimental to soil health in Ukraine, which could have implications for agricultural productivity and crop nutritional quality. In addition, concentrations of some contaminants were over safe limits, indicating a potential risk to human health, and the health of the local ecosystem. Thus, a comprehensive monitoring scheme and appropriate remediation measures are required, particularly for areas identified as at being at exceptionally high risk.

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High-Resolution Mapping of Soil Properties Across Scotland Using Machine Learning: Insights into LOI, pH, and Bulk Density

By Adnan Khan

Abertay University

Understanding soil properties is fundamental for sustainable land management and environmental conservation. This study presents high-resolution (10m) predictive maps of three critical topsoil properties Loss on Ignition (LOI, %), pH, and bulk density across Scotland. These maps were developed using machine learning techniques, providing detailed spatial insights essential for agricultural planning, carbon sequestration assessment, and ecosystem health monitoring.

The study involved the collection of 250 soil samples from diverse landscapes across Scotland, employing Conditioned Latin Hypercube Sampling (CLHS) to ensure representative and comprehensive coverage. The samples were meticulously analysed: LOI was determined as an indicator of organic matter, pH was measured using a digital pH meter to understand soil acidity or alkalinity, and bulk density was assessed through the core ring method to evaluate soil compaction.

Machine learning models were then trained on these data, incorporating various environmental covariates to predict the spatial distribution of these soil properties. The resulting maps reveal significant variability in soil characteristics, highlighting regions of high organic matter, optimal pH for agricultural productivity, and variations in soil density that impact water retention and root penetration.

Keywords: Soil properties, Machine learning, Loss on Ignition, pH, Bulk density, High-resolution mapping, Scotland, Sustainable land management, Carbon sequestration.

Funded by: Norman Fraser design trust and Scottish government

Link to Poster

Fabrication and performance evaluation of a biofertilizer prototype via a sustainable and bacteria-friendly process

By Aileen Grace Ongkiko

Université Claude Bernard Lyon 1/University of the Philippines Diliman

The excessive use of synthetic fertilizers has led to the substantial soil degradation and adverse impacts on soil health. As an eco-friendly alternative, biofertilizers offer a sustainable solution by using plant growth-promoting bacteria to support plant development. This study presents the fabrication of a biofertilizer prototype based on Azospirillum baldaniorum Sp245 immobilized within a novel chitosan/carrageenan carrier matrix. Designed and formulated through polyelectrolyte complexation mechanism, this carrier matrix not only ensures bacterial viability but also has the potential to enhance soil conditioning, using chitosan's recognized properties as a natural soil conditioner. The biofertilizer was developed through a bacteria-compatible process, optimized to ensure bacterial survival, prolonged release, and efficient root colonization. Scanning confocal microscopy confirmed bacterial immobilization, while prolonged bacteria release profiles were monitored over three months, uncovering a hypothesized potential for bacterial re-entry into the polymer matrix. This further reinforces the bacteria-compatibleness of the matrix even after the initial bacteria release.

Plant growth was evaluated using in vitro and greenhouse in vivo studies on wheat seeds where root colonization by A. baldaniorum Sp245 was again verified via scanning confocal microscopy. Key growth parameters, including biomass and root morphology (i.e. root/shoot ratio, number of root tips, root length, root surface area, and root diameter), were carefully measured, with root characteristics analysed through WinRhizo software. Shapiro-Wilk test, ANOVA, and non-parametric post-hoc tests were performed to determine significant statistical effects of the application of the biofertilizer prototype to these plant characteristics. The gathered results demonstrated a successful bench-scale production of a biofertilizer prototype that enhances plant growth without reliance on synthetic fertilizers. The prototype not only supports sustainable crop development but also contributes positively to soil biodiversity and fertility contributing to the advancement in agricultural technology.

Keywords: biofertilizer, plant growth promoting bacteria, Azospirillum baldaniorum Sp245, chitosan, carrageenan, polyelectrolyte complexation

Funded by: Engineering Research and Development for Technology of the Department of Science and Technology of the Republic of the Philippines

Long-term effects of biochar on soil microbial activity and health

By Daniel Nowakowski, Adam El-Aradi and Agnieszka Nowak

Aston University

Biochar, a carbon-rich material produced through biomass pyrolysis, is of considerable interest because of its potential to enhance soil health and biodiversity. Its porous structure and high surface area allow biochar to improve soil's physical, chemical, and biological properties. Specifically, biochar increases soil aeration, water retention, and aggregation, which support root growth and reduce soil compaction, particularly in degraded soils. In addition to these physical improvements, biochar also influences soil chemistry by increasing cation exchange capacity and nutrient retention. Biochar enhances the availability of essential nutrients and can raise soil pH, creating more favourable conditions for plant growth. Biologically, biochar positively impacts microbial activity by providing habitats for beneficial microbes, enhancing nutrient cycling, and promoting plant-microbe interactions.

This study aimed to analyse the long-term effects of biochar on microbial activity and health of agricultural soil. Two types of biochar (derived from the pyrolysis of wheat straw and pine wood) were used in this study. Biochar was added to the soil at concentrations of 1%, 2.5%, and 5% by volume, with untreated soil serving as the control sample. Key parameters monitored included the number of heterotrophic bacteria, dehydrogenase activity, and functional diversity indices using 96-well Biolog® EcoPlates™ containing 31 carbon sources.

The results indicated that dehydrogenase activity and substrate oxidation indices from the EcoPlates™ were the most sensitive indicators of biochar's impact. Notably, a significant increase in dehydrogenase activity was observed after three months, with the highest activity in soil amended with 5% biochar derived from wheat straw pyrolysis. The effects of biochar vary depending on the feedstock and soil conditions, highlighting the need for further research on biochar post-processing or modification ("biochar engineering") to optimise its application for improving soil health.

Keywords: Biochar; Soil health; Pyrolysis; Microbial activity; Heterotrophic bacteria; Dehydrogenase activity; Functional diversity.

Funded by: Biochar CleanTech Accelerator (West Midlands Innovation Accelerator)

An improved method for measuring peatland soil oxidase enzyme activities

By Douglas Baah

Ulster University

Background: Recent reports indicate that lowering the water table due to drainage or drought has shifted peatlands' net carbon (C) balance, turning many into carbon sources by accelerating decomposition. Conventionally, it is established that there is positive feedback between water-level drawdown and extracellular enzymes which mediate soil organic C mineralisation and dissolved organic C (DOC) transformation. Soil oxidase, the oxygenenhanced extracellular enzyme, is recognised as a key factor promoting the breakdown of complex aromatic soil organic matter (SOM) such as lignin compounds under water-level drawdown. However, unlike hydrolases which are extensively studied and assayed in soil, there are few papers dealing with oxidase measurements. Therefore, this study uses a modified method to report the activity of soil oxidase; phenol oxidase, and peroxidase under different peatland treatments.

Approach: Soils were collected from temporary sampling plots established in different peatland treatments (drained, forest-to-bog restoration) for laboratory analysis. Due to varying oxidative enzyme activities across soils and substrates, a negative control could help assess the impact of abiotic factors like soil mineralogy. However, negative controls in these assays have been inadequately evaluated. This research takes advantage of a novel modified method to measure the activities of phenol oxidase and peroxidase using 2,2′-azinobis-(-3-ethylbenzothiazoline-6- sulfononic acid) diammonium salt (ABTS) as substrate. In addition, factors such as soil condition (dry or fresh weight) that could affect their activity measurement were also investigated to optimise conditions for the ABTS assay.

Significance of study: As peatland conservation is continuously threatened by anthropogenic activities, understanding the nexus between soil enzymes and peatland use becomes crucial for developing effective conservation management and restoration approaches.

Keywords: ABTS, Autoclaved Samples, Carbon cycle, Climate change, Drained Peatland, Enzyme Assay, Peatlands, Phenol oxidase, Peroxidase, Recalcitrant Compounds

Funded by: Ulster university Vice Chancellor's Doctoral Research Fellowship

Link to Poster

Spatial and temporal evaluation of greenhouse gas fluxes in rewilding sites: implications for carbon sequestration

By Efe Okekporo

University of the West of England

Background: Rewilding is an emerging concept in ecosystem management, which involves regenerating the wildness of degraded landscapes, with less emphasis on the historical benchmark and greater focus on environmentally driven transformation. Because changes in soil organic carbon (SOC) are usually not observable until more than ten years, assessment of rewilding climate change mitigation success in the short term is difficult without alternative methods. To evaluate the long-term impact of rewilding, especially on greenhouse gas (GHG; carbon dioxide and methane) emissions and changes in SOC, there is a need to develop suitable measurement/monitoring, reporting, and verification (MRV) capabilities.

Aim: To develop MRV capabilities to assess the effect of rewilding on changes in SOC by evaluating spatial and temporal GHG fluxes, and physicochemical/biogeochemical soil processes.

Method: Due to the tall vegetation at the rewilding site (Sheepdrove organic farm, Lambourn, England), a transparent chamber (≥ 1.5 m tall) was constructed to evaluate the spatial and temporal net ecosystem exchange of GHG fluxes using a Li-Cor 7810 gas analyser. 28 collars were installed (50 meters apart in a grid) for the 3 spatial sampling campaigns. Semivariogram and Kriging (Arc GIS) determined the minimum number of independent sampling replicates (8) for the temporal sampling. Temporal monthly measurements of GHG fluxes and soil physicochemical parameters including bulk density, texture, water-extractable nutrients (anions and cations), Total Carbon/Total Nitrogen, pH, and % moisture content are ongoing. Furthermore, monthly biotic measurements including soil enzymes (glucopyranosidase, phosphatase, glucoseaminidase), microbial biomass (chloroform fumigation), dsDNA extraction and qPCR for bacterial/fungal ratios, and basal soil respiration are continuing. Additionally, the HOBO RX2100 Station measures meteorological data including air temperature, rainfall, photosynthetically active radiation, wind speed/gust, and soil moisture/temperature.

Keywords: Greenhouse gas fluxes, carbon dioxide, methane, spatial/temporal sampling, rewilding, enzymes, Soil Organic Carbon, semivariogram, Kriging, nutrient cycling, bacteria/fungi ratio.

Funded by: UWE Bristol, Wild Carbon

Link to Poster

Plant pests influence the movement of plant-fixed carbon and fungal-acquired nutrients through arbuscular mycorrhizal networks

By Emily Magkourilou

University of Sheffield

Introduction/Aim: Plants typically interact with multiple, co-occurring symbionts, including soil-borne arbuscular mycorrhizal (AM) fungi which can form networks, connecting neighbouring plants. A characteristic aspect of the mycorrhizal symbiosis is the bi-directional exchange of nutrients between host plants and fungal partners. Concurrent interactions with competing organisms such as aphids or plant-parasitic nematodes can disrupt the carbon-for-nutrient exchange between plants and AM fungi. However, the role of below-ground mycorrhizal networks in mediating these interactions remains unclear.

Materials and Methods: Using isotope tracing in multi-plant experimental systems, we investigated the movement of plant photosynthates and fungal-acquired soil phosphorus through mycorrhizal networks and the effect of plant nematode infection on this.

Results: We found evidence of preferential allocation of fungal-acquired soil phosphorus to plants that were not infected by nematodes compared to infected neighbours. Contrary to previous findings using single plants, we detected no nematode-induced reduction in the amounts of plant carbon delivered to AM fungi in multi-plant systems. However, once plant carbon was below ground, the mycorrhizal network(s) moved more of this carbon away from the nematode-infected host plants when these were present.

Discussion: Our work highlights the responsiveness of mycorrhizal networks to interactions with below-ground organisms. It also strengthens the argument for a more mycocentric view of AM-plant symbioses.

Conclusions: Experimental designs of increasing ecological complexity are needed for a more comprehensive understanding of the carbon-for-nutrient dynamics in AM fungi-plant networks. This will, in turn, elucidate the role of AM fungi in terrestrial carbon cycling and their function in agricultural systems.

Keywords: arbuscular mycorrhizal networks; biological markets; carbon-for-nutrient exchange; competition; mutualism; soil carbon; soil ecology

Funded by: BBSRC; The de Laszlo Foundation

Link to Poster

Do legumes contribute to the productivity and resilience of semi-arid savanna grasslands via influence on soil function?

By Fiona Pearce

Lancaster University

In sub Saharan Africa, grasslands are vital for food production and rural livelihoods, with approximately 70% of people in rural areas dependent on livestock grazing. Grassland ecosystems also have high cultural and biodiversity value. However a significant proportion of grasslands in this region are in a degraded state, often due to overgrazing. This can cause depletion of organic matter and nutrients, disruption to soil ecology, and degradation of soil structure, leading to soil erosion and reduced plant productivity. Degraded soils and grasslands are also less resilient to climate extremes, with drought being a particular challenge for grasslands in semi-arid areas, posing a threat to food security. It is therefore crucial that we understand how best to restore degraded soils to good condition.

While there is a significant body of research on temperate grassland soils in Europe and North America, and semi-arid grasslands in Asia and the Americas, there has been little research on the function and restoration of grassland soils in sub Saharan Africa. These soils may be expected to respond differently to management and restoration approaches due to being much older and highly weathered, and often naturally low in carbon and nutrients.

Re-seeding to restore grasslands is often focussed on grasses, but natural grasslands comprise multiple plant functional groups. It is hypothesised that legumes play an important role in the productivity and drought resilience of nutrient-limited semi-arid grasslands due to their nitrogen fixing ability and rooting strategies. Using a mesocosm experiment, we assessed the impact of drought on the health of semi-arid grassland soils, and evaluate whether increased plant diversity, specifically the inclusion of legumes, mediates the impacts of drought. Data are currently being collected and we will be able to present the results at the conference.

Keywords: grassland; restoration; semi-arid; drought; grazing; degradation; legumes; diversity

Funded by: Envision DTP, International Livestock Research Institute

Link to Poster

Investigating the nitrogen acquisition strategies of microbes and clustering of functional genes along a pH gradient in an entic humic podzol.

By Jack Horne, Fiona Fraser, and Christine Watson

University of Aberdeen/SRUC

Soil pH has been altered throughout history to improve its agronomic output. The pH of soil affects many of its characteristics, including nutrient availability, microbial community composition, and functional gene abundance. However, research has largely neglected the impact of soil pH on how soil microbial communities adjust to chemical pressures in the field, and subsequently how communities cycle and acquire resources such as nitrogen. The aim of this project is to identify key functional genetic markers that coincide with greater rates of organic nitrogen cycling, increased rates of resource acquisition in microbes and understand how short- and long-term pH manipulation affects the investiture of the microbiome into these key functional genes. This study utilises a long-term field experiment of soils that have had their pH adjusted to values between 4.5 and 7.5 in intervals of 0.5 over 63 years, and a paired set of soils that have had their pH adjusted for 3 years. Soils were analysed for the nitrogen resource availability and the microbial biomass carbon and nitrogen through chloroform fumigation. Results show there were linear increases in microbial biomass nitrogen with increasing soil pH in a field setting, while there was no concurrent increase in microbial biomass carbon. This suggests that soil microbial biomass size remains stable over the studied pH range, but microbial nutrient acquisition strategies may change. Subsequent analyses of metagenomic sequences of subsamples from the pH 4.5, 6.0, and 7.5 treatments will analyse the clustering of functional gene abundance to each treatment and linking this to the resource availability. The combined analysis will allow us to understand the possible utility of the soil microbiome in future sustainable soil management.

Key Words: Nutrient dynamics, Microbiome, pH, Nitrogen, Functional Genes, Biochemistry, Metagenomics

Funded by: UKRI BBSRC

Natural England delivering for Soil Health

By Jonathan Griffiths[1], *Eleanor Reed*[1], *Matthew Shepherd*[1] and *James Hughes*[1]

[1]Natural England

Soil health is a measure of how well soil functions to deliver the ecosystem services that are best suited to it. Natural England's Soils team has identified a number of key steps required to progress the UK government's aims to deliver soils that are sustainably managed by 2030 and to map and monitor soil health. To progress these aims we have been delivering an increasing number of projects to deliver soil data, knowledge, tools and guidance to contribute to improving soil health and supporting nature recovery.

We here present an overview of these projects and show how they align with the following themes.

- Soil data and mapping
- Land use and planning
- Impacts of land/soil management
- Reducing soil threats
- Promoting better practices for soil use and management
- Soil survey and monitoring
- Soil awareness and understanding for policy, science and people.

The aim is to increase sustainable soil management to meet or exceed government targets. We define sustainably managed soils as those which meet minimum standards for, and do not decline in soil health, and which require minimal interventions to continue to deliver the services best suited to them.

Link to Poster

Ammonia emissions drive changes in soil biogeochemistry and microbial communities along a tree shelterbelt.

By Katie Somerville-Hall

University of Reading

Agriculture produces 87% of ammonia (NH3) emissions in the UK, contributing to the exceedance of critical nitrogen deposition loads. Tree shelterbelts can be planted around agricultural emission point sources to intercept NH3, reducing dispersion to the wider environment. This study aimed to determine the impact of NH3 emissions on soil biogeochemistry, and fungal and bacterial community composition and richness under a thirteen-year-old shelterbelt on a poultry farm in Cumbria, UK. Aboveground tree data and soil samples collected from the shelterbelt with distance from the poultry housing were used to evaluate the effect of NH3 emissions. Soil pH and nutrient availability under the tree shelterbelt significantly increased ($p < 0.001$) with distance from the poultry housing, while soil organic carbon decreased within the shelterbelt ($p < 0.05$). The community composition of soil fungi and bacteria (ITS, LSU, and 16S primers) significantly shifted with distance from the housing ($p < 0.001$), highest correlated with changes in soil pH, phosphate, C/N ratio and ammonium, plus nitrate for bacteria. The genus richness of bacteria, arbuscular fungi and saprotrophic fungi significantly increased with distance from the housing ($p < 0.05$). We found that NH3 emissions significantly impact soil chemistry and microbial community composition, and reduce richness under a tree shelterbelt. This study advances our understanding of the impacts of NH3 emissions on soil biogeochemistry in shelterbelt ecosystems, crucial to understand for their broader implementation to reduce the ecological damage caused by excessive NH3 emissions.

Keywords: agroforestry, ammonia mitigation, soil microbial community, soil bacteria, soil fungi, mycorrhizal fungi, soil organic carbon, nitrogen, soil acidification

Funded by: Natural England, UK Centre for Ecology and Hydrology, Forest Research

Link to Poster

Biodegradable Plastic Mulch Films as an Opportunity to Improve Soil Health

By Liberty O'Brien, Charlotte Lloyd, and Martin Blackwell

University of Bristol

Plastic mulch films (PMFs) play an important role in maintaining food security by optimizing growing conditions, resulting in increased crop yields and reduced reliance on agrochemical inputs. However, growing environmental concerns regarding petrochemical-based microplastics have provoked commercial interest in biodegradable alternatives. Despite this, scientific understanding of the biodegradability of biodegradable PMFs in natural environments and their impacts on agroecosystems remains limited, which could compromise their perceived benefits as environmentally friendly products. This research project aims to close this knowledge gap whilst focussing on the potential positive impacts of these carbon-rich materials on soil health. The primary objectives are: (1) to quantify the degradation of biodegradable PMFs within agroecosystems, (2) to assess the impact of these films on soil health indicators, and (3) to identify methods for improving the impact of biodegradable PMFs on soil health and the sustainability of agricultural systems.

To achieve these aims, a combination of laboratory and field-based experiments will be conducted. Field trials will monitor biological, chemical and physical soil health indicators in response to biodegradable PMFs over multiple growing seasons. High-resolution molecular-scale chemical analysis will be utilised to improve upon traditional methods, including ^{13}C stable isotope probing to enable precise quantification of biodegradation and chemical elucidation to identify relationships between chemical additives or contaminants and soil health indicators.

As well as producing valuable data for environmental and agricultural policy making, this project has the potential to guide commercial manufacturers towards a more sustainable and useful product, making important steps towards realistic solutions for improving the sustainability of large-scale food production.

Keywords: biodegradable plastic mulch films, soil health, microplastics, stable isotope probing, GC-MS

Funded by: BBSRC (SWBio DTP)

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Are Earthworms a Useful Proxy for Soil Health?

By Louisa Moor

University of East Anglia

Despite the plethora of biological life in the soil ecosystem, earthworms are frequently used as the only proxy of soil biological status. This research will use in-depth measurements of other biological indices, applied to soils under contrasting land management regimes, to evaluate the validity of earthworms as bioindicators of soil health. Physicochemical properties of soil texture, soil organic matter (SOM), water stable aggregates (WSA), and visual evaluation of soil structure (VESS) will provide a context to the biological assessment. To build out the biological assessment wider mesofauna characterisation and eDNA analysis directed will complement earthworm counts. Invertebrate profiles in the soil are becoming increasingly considered as bioindicators of soil health. Thus, modern pitfall trapping will be used to evaluate soil mesofauna.

Further, a PCR-based metabarcoding methodology will be used to assess 16S rRNA genes and Internal Transcribed Spacer (ITS) amplicon sequencing directed towards bacterial and fungal diversity, respectively. Data will provide a holistic understanding of soil properties that contribute to soil health, with emphasis on the soil as an ecosystem made up of a variety of biota. The research will establish correlations between soil edaphic factors, under contrasting land use regimes, and the broader gamut of biological indictors. By the time of the conference, we will have result to engage the question posed.

Funded by: The Morley Agricultural Foundation (TMAF)

Return of the Golden Hoof: Sheep, Sustainability and Soil Health

By Luke Harrold

SRUC (Scotland's Rural College)

The grazing of sheep on winter cereals intended for sale used to be common practice. The rise of modern agriculture has seen the disintegration of the once integrated crop-livestock systems as well as a decrease in soil health. As pressure grows to find more sustainable alternatives to modern agricultural practices, the reintegration of livestock and arable farming has come back into the limelight.

To evaluate the feasibility of grazing sheep on winter cereals, trials were established over three years in northeast Scotland as well as at several participating farms in the region with grazed and ungrazed sites. It was hypothesised that this practice would provide adequate feed quality and quantity to sheep while incurring no detriment to yield and potentially improving soil health. We found that even at the highest grazing intensity, where forage was grazed to bare soil, there was no yield penalty incurred at harvest time.

We also observed reductions in severity of plant disease, increases in earthworm abundance and no impact on VESS scores in grazed sites. The results show that this practice can help ease the winter feed gap while providing no detriment to yield and may help improve soil quality and potentially help reduce reliance on synthetic inputs.

Funded by: EU Horizon 2020 MIXED

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Exploring Soil Health Through Collaborative Management: Findings from the 5-Year Soil Health Project

By Tom Ormesher, Bethany Fairley, and Stephen Woodley

Southern Water

The 5-Year Soil Health Project (2017-2022) involved detailed soil health monitoring across ten farms in the Farmer Cluster. Annually, over 2,000 soil samples were taken from 336 hectares and analysed for organic matter, soil mineral nitrogen, pH, nutrient availability, and microbial activity. The project identified several key findings: farms with livestock had 8.3% more organic matter, 42.6% higher earthworm counts, and 18.7% more available potassium than those without livestock, likely due to manure inputs. Inversion tillage resulted in 9.8% higher soil organic matter, 37.4% higher earthworm counts, and 24.3% more potassium at 0-30 cm depth than minimum tillage. The soil health index was also higher in both scenarios, 3.2% and 6.2%, respectively. Additionally, soil organic matter and microbial respiration were strongly correlated with phosphorus, potassium, and nitrate availability. Earthworm counts were positively linked to nutrient availability, providing a visible indicator of soil health. These results emphasise the role of livestock and appropriate tillage practices in enhancing soil quality and productivity while demonstrating the effectiveness of collaborative soil health monitoring in promoting sustainable farming.

Keywords: soil health, organic matter, nutrient availability, microbial activity, livestock, tillage, earthworms, sustainable farming, soil monitoring

Funded by: Southern Water

The effect of soil nitrogen mineralisation by employing organo-mineral fertiliser on Spring wheat crops

By Parveen Fatemeh Rupani, Ruben Sakrabani, and Wilfred Otten

Cranfield University

Farmers increasingly rely on nitrogen fertilizer to meet the rising agricultural demands of recent population growth. Often, it is reported that 50% of the applied N losses during agriculture activity are due to leaching and denitrification. Organic fertiliser could be a promising alternative; however, low nutrient concentrations in organic matter and a very large application rate limit its efficient application on the land. Therefore, there is a growing interest in the application of combining both fertilisers as organo-mineral fertilisers, known as OMF. Substantial scientific evidence shows that combining organic with synthetic N fertiliser leads to more efficient nutrient uptake by plants and decreased N losses in the environment. Furthermore, applying OMF will enhance soil health by increasing soil organic carbon. Its slow-release nutrient effect allows the fertilizer to remain in the soil for a longer period, leading to improved soil health.

This study focuses on the application of a sub-optimal level of 10%N OMF on spring wheat growth development. In this study, OMF was made with the combination of ammonium nitrate and digested (from organic waste) using carbon capture technology. Application of different doses of OMF, including 45, 60, 75 and 90 %, were compared with 100% mineral fertiliser in 4 replicates in a glasshouse study on 24 lysimeters.

The findings of this study showed no significant differences in nitrogen mineralisation between treatments. our results suggest that the sub-optimal doses of OMF applied are comparable to 100% mineral fertiliser. It is anticipated that improved soil health will provide a suitable environment for root establishment to access nutrients from mineralising OMF. However, due to the short time frame of spring wheat application, further investigation is required for a longer growth time or successive wheat growth seasons. Moreover, measurement of N2O in gaseous form is essential to conclude the potential N loss.

Organo-mineral fertilisers for British farming: results from 4 preliminary field trials

By Patrick McKenna, and Bea Burak

Cranfield University

Arable farming in Great Britain relies significantly on applications of mineral N, P and K fertilisers. Although essential for productivity, these fertilisers do not contribute to non-nutrient aspects of soil health, for example soil organic matter and structure. Organo-mineral fertilisers (OMFs) are novel fertilisers which combine conventional mineral fertiliser with carbonaceous organic waste materials, such as crop residues, brewery waste or chicken litter. OMF has the potential to provide nutrients for crops and organic material for soil, sustaining both arable yields as well as soil health.

Four randomized block design field trials were established in 2021 to investigate the effect of OMF on crop performance, soil health and root growth. The crops selected were winter wheat, spring barley, oilseed rape and oats. OMF with varying mineral and organic feedstocks were applied (ammonium nitrate, urea, DAP, and organic feedstocks including green compost, food waste, crop digestate and chicken manure). Control plots with only conventional mineral fertilisers applied were also included. Soil nutrients and organic matter were assessed before and after the trials and crop performance was assessed as the final grain yield.

No significant results were observed for soil health properties assessed. The crop yield assessments remains ongoing but so far it appears as though there are no significant differences between the type of OMF used, and no difference between the OMF treatments and the arable control. The research will highlight the suitability of OMF for use in British farming. This work was carried out by Bea Burak at Yara and Cranfield University but will be presented by Patrick McKenna.

Keywords: Organo-mineral fertiliser (OMF), nutrient management, circular economy, fertility management

Funded by: YARA and Innovate UK (KTP)

Link to Poster

Soil organic matter distribution into particulate and mineral-associated forms across land use intensity gradients in temperate soils.

By Rugveda More, Lisa Cole**,** Ashish Malik, and Jeanette Whitaker

University of Aberdeen

Soil organic matter (SOM) persistence primarily depends on the balance of microbial decomposition of plant organic matter and mineral stabilization of the microbially processed organic matter. Land use intensification is known to cause soil carbon loss. The extent of this loss depends on soil properties such as soil pH and moisture, but the mechanism remain poorly understood. We hypothesised that acidic wet soils have much higher soil carbon due to accumulation of undecomposed organic matter (particulate organic matter or POM) which is lost on land use intensification, while alkaline drier soils have much higher proportion of stable mineral-associated organic matter (MAOM) and hence a lower relative decline in soil carbon on land use intensification. To test these hypotheses, we sampled soils from 28 UK sites with paired land use contrasts, isolated SOM fractions using physical separation and analysed for carbon. The results were correlated with a range of soil properties including pH, soil moisture, clay content, microbial biomass and carbon use efficiency. We present how SOM fractions respond to variations in soil and microbial properties across land use intensity gradients to understand the balance of organic matter decomposition and stabilisation processes. We observe that acidic soils under low land use intensity accumulate more POM as microbial growth is constrained by cool, wet and acidic soil conditions. In contrast, soils with neutral to alkaline pH under low land use intensity have a microbiome with higher carbon use efficiency, and the resulting higher microbial necro-mass is stabilised in the MAOM fraction. We show that increased land use intensity causes higher SOM losses in acidic soils where POM decomposition can be rapid, highlighting the need to protect vulnerable POM stores in acidic wet soils. The microbial production of more stable MAOM in croplands can help store carbon and improve soil health.

Self-funded- MSc by Research

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The soil microbiome in restoration programmes is shaped by antecedent land use

By Samuel Hibdige

Cranfield University

Metagenomics is a powerful tool for exploring the microbiome of soil. Whilst more commonly used in an agricultural context it has so far been underutilised for conservation purposes. This widescale multidisciplinary project aims to explore the relationship between complexity and resilience in restoration of habitats. Whilst the project overall examines many factors, one of the key aspects it explores is how the soil microbiome helps shape this.

One Hundred and Twenty restored habitat sites across the UK where sampled for a number of biotic measurements including soil sampling. These captured a variety of ages since restoration, former land use (FLU) and final states. Amplicon sequencing was used to determine the composition of both bacterial and fungal communities and was paired with chemical measurements of the soil. By examining changes in relative abundance and inferred functional capacity between sites, we were able to see how restoration trajectories of the microbiome are limited by their past.

Stark differences in the microbiome were detected in restored woodlands even after 70 years that correlate with former land use. Not only were the bacterial and fungal communities different between former land use practises, but also demonstrate different trajectories entirely without converging to a single "restored" point. Whilst restoration included many shared functional profiles, each FLU had a number of unique functional pathways that separated them from ancient woodland sites.

Funded by: NERC

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Visualising soil as living organism

By Daro Montag, and Martin Blackwell

Falmouth University

Rothamsted hosts one of the world's most extensive continuous land management research projects. It also holds one of the oldest archives of soil samples dating back to the 1840s.

Working alongside soil scientists at Rothamsted the artist, Daro Montag, has undertaken a short residency at their farm in North Wyke.

Various soil samples from the archive have been subjected to a novel technique of imaging developed by Montag. This technique enables the micro-organic constituents of soil to imprint a trace of their activity within pre-processed films.

By making visible the abundance of living matter in soil, the brightly coloured artifacts, known as 'bioglyphs', help to bridge the gap between art and science. They highlight the fact that soil is not simply a collection of inanimate particles, but a richly teeming matrix of life. This collaboration between the disciplines provides a highly visual and easily accessible way to appreciate the complexity of living soils.

Animating Soil Health: Breathing Life into Soil, Campaigning through Stopmotion Film & Ceramics

By Jo Pearl

EcoArtSpace

Our visual understanding that soil is healthy is generally gathered by reading how green a landscape is, how lush the plants growing there are. There is little understanding in the general public that soil is a highly complex biome. Making the invisible, visible is one of the artist's key roles in society, including what may be hiding just beneath our feet: like the awe-inspiring biodiversity in healthy soil.

In this multidisciplinary session, an independent artist will share a short stop-frame animation about soil biodiversity and discuss how clay in its plastic state or subsequently kiln-fired, can breathe life into the topic of soil biomes, as well as show the timeless significance of this subterranean world.

In the project 'Unearthed,' the presenter draws the viewer's perspective down to examine the choreography of ever-more tiny beings that inhabit the soil through material-rich, claymation. Being part of soil, clay is a highly appropriate and resonant medium to explore this topic. Using stopframe animation is a way to bring humour, delight and the possibility of bridging two seemingly separate worlds of humans above ground and the microbes and fauna below.

After the short screening [with a running time of 4 minutes 24 sec] the artist will discuss the potential of art activism to change mindsets about soil: by bringing ideas to life, revealing hidden beauty, and catching audiences off guard.

This session asks: When nature can be off-putting and statistics too dry, how can we enchant a germaphobic, modern audience about soil? Do animation and clay have a special role to play in bringing the subject to life, and campaigning against practices that cause soil depletion?

For Peat's Sake - can we use local expert knowledge to generate new land management opportunity maps in lowland peat landscapes?

By Megan Hudson, Elizabeth Stockdale

Fenland SOIL Ltd

In the UK, Local Knowledge of Landscape and Soils (LSK), defined as "knowledge of soil properties and management processes possessed by people living in a particular environment for some period of time" has rarely been a core component of soil assessment or land management policy.

Mounting evidence shows:

1.) The value of LSK integration into participatory soil surveys.
2.) Exclusion of LSK often results in the failure of scientific interventions to improve land use.

The project team set out to assess the feasibility of bringing together local expert knowledge, particularly LSK, of farmers, land managers and drainage experts to tackle carbon loss in the East Anglian Fens. The aim was to unlock barriers to re-wetting and restoration by developing co-created opportunity maps, presenting land managers with a mosaic of options for changing land-use or land-management. Changes to land-management in the Fens will require close cooperation to ensure a realistic and feasible plan, which reduces emissions, prioritises food security, enhances biodiversity and maintains the landscape for the people that live, work and travel there.

The project team consulted farmers to create catchment wide mapping layers for soils, agricultural productivity and hydrology at field scale. This information was collated and used to generate a field-by-field opportunity map tool that farmers and other stakeholders can use to inform future practice. This roots-upwards approach showed that farmers can help design achievable solutions and reaffirmed the need to consult local experts when designing complex landscape-scale change, to quickly narrow down scoping, allowing resources to be used where there is greatest chance of success. The initial pilot covered an area of 11,000 ha, with a further 65,000 to be mapped by January 2025, as well as supporting the adaptation of the methodology for other areas of lowland peat.

Keywords: peat, LSK, local knowledge, participatory, agriculture, net-zero

Funded by: Natural England/ Environment Agency/ Cambridgeshire and Peterborough Combined Authority

Strengthening bridges between academic research and agricultural practice - taking Welsh farmers with us on the soil carbon journey

By Non Williams

Farming Connect

Soil is the most valuable natural resource on a farm. The diversity of Welsh soils, and subsequently, the variability in soil carbon stocks is driven by a number of factors, including climate, land use and management practices. Protecting soil carbon is a priority for the Welsh Government, and farmers are becoming increasingly interested in quantifying and understanding their soil carbon stocks. Data gathering and exchange of knowledge on soil carbon may also help farmers understand the importance of managing soils in a manner that will have a positive impact on soil health, microbial activity, nutrient supply, and crop/pasture yields.

By utilising information from existing projects and learning from academic researchers, a Pan-Wales project focusing on estimating soil organic carbon stocks was set-up, and was replicated across multiple fields from varying farming systems (n=56). In addition to detailed soil sampling, a survey questionnaire was completed on a one-to-one basis with the farmers at project outset capturing their knowledge, observations and thoughts on the management/status of each field within the project.

Data analysis is currently ongoing between the Project Officer and researchers, and the findings will be shared with the farmers in due course. This collaborative approach involving various actors in the agricultural sector, including research institutes, farmer groups and advisory services will help bridge the gap between soil science and practice within the sector.

Results analysed post abstract submission will enable us to better understand the link between soil carbon stocks on Welsh farms and farmers' motivation for land management decisions.

The project's findings will be relevant to the wider agricultural industry in Wales and beyond, and will aid with bringing farmers with us on the journey of learning more about management-soil interactions, which may result in a behaviour change to support sustainable soils and net zero targets.

Funded by: Welsh Government

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An integrated social and natural sciences case-study for the reuse of organic wastes as soil amendments

By Andrea Garduno Jimenez, Laura Carter, and Katie Field

University of Leeds

The reuse of organic waste materials, e.g. animal manure, as soil amendments reduces agricultural demand for water, energy and nutrients and aligns to a circular approach to agriculture and delivery of the Sustainable Develop Goals. However, organic wastes may contain chemicals of emerging concern (CECs), which present a risk to ecosystem and human health. Open dialogue between researchers studying CECs and the farming community to increase awareness about the potential risks and to discuss best practice is lacking. Furthermore, farmers face financial and policy barriers and drivers to use (or not) these materials which often do not consider wider environmental concerns. Therefore, an integrated approach that combines research into CEC presence and its effects on key soil functions (i.e. mycorrhizal colonization), with perspectives from social anthropology research was undertaken. A UK farm using wastewater biosolids, manure and synthetic fertiliser on three different fields is presented as a case study and outputs include a recorded interview with the farm owner and manager to reveal the practicalities, drivers and barriers of using different soil amendments. This work presents chemical, biological and social considerations around soil amendment choices, and stakeholder identified research questions following a UK-wide stakeholder workshop.

Keywords: stakeholder engagement; contaminants of emerging concern, mycorrhizal fungi; soil health

Funded by: White Rose

Link to Poster

Soil SMArt: Pioneering Citizen-led Co-Design for Sustainable Soil Health Monitoring

By Charlotte Chivers, Chris Short, and Kirsten Mills

Countryside & Community Research Institute, University of Gloucestershire

This session will provide an overview of the innovative co-design process used for Soil SMArt, a citizen-led science project which is developing a framework for achieving long-term soil health monitoring. By centring on the active involvement of citizens, primarily agricultural land managers, from the project's inception, Soil SMArt exemplifies a collaborative approach where participants shape and design monitoring systems tailored to their specific needs and interests. The co-design process has included various workshop sessions where citizens have undergone selection processes to determine their preferred soil tests, training requirements, and equipment needs. They were also guided in choosing an appropriate soil health monitoring platform. Each stage of co-design balanced the preferences of both scientists and citizens, utilizing negotiation to ensure mutual benefits and participant satisfaction.

The project is employing a comparative methodology, gathering high-level research-grade monitoring data and mid-level agronomist-collected data alongside citizen-gathered data. Additionally, communication strategies, co-designed with references to Guasch et al. (2022) and Pelacho et al. (2023), aim to ensure that monitoring results are relevant and actionable for citizens, offering bespoke advice and recommendations to land managers. Here, acceptable uncertainty levels in citizen-collected data will be negotiated to identify an acceptable range of accuracy, thus determining its potential utility for informing outcomes such as on-farm advice and practical recommendations.

Interviews with participants—including citizens, researchers, and scientists—will provide insights into the utility and limitations of citizen-led science and the effectiveness of co-design in such initiatives. This presentation will share key findings and experiences from Soil SMArt to date, highlighting citizens' suggestions for sustaining engagement. Insights from Soil SMArt will be integrated with those from a related CAstCo project, River Guardians, to formulate comprehensive guidelines for co-designing citizen-led science applicable to broader environmental monitoring efforts.

Funded by: CAstCo (Southern Water)

Unmaking and Making a Fertile Soil: Exploring soil fertility management amongst smallholder farmers in Ghana.

By Eugene Setsoafia

Wageningen University and Research

Drawing on Social Practice theory, we explore the materials, competences and meanings of soil fertility management practices implemented by farmers in three regions in the North of Ghana. In these regions, widespread deficiency in both macro-, meso- and micronutrients has rendered the soil unproductive and, in some cases, non-responsive to mineral fertilizers. Applying mixed methodologies including farmer observations, interviews and on-farm farmer managed trials, we critically examined the implementation of mineral fertilization, mulching and manuring. We found that the level of mulch application in terms of land area covered did not differ significantly across the locations. Manure was applied below the recommended rate in most cases. Mulching and organic manure application offered opportunities for improving crop performance (grain yield) but smallholder farmers' ability to implement these agronomic practices was highly heterogenous at geographical levels and so were the impacts on grain yield. The application of mulch and manure were severely constrained by their availability to farmers, labour and capacity to collect, store and transport mulch and manure and the effective implementation of weed management. Declining soil fertility, the high cost of mineral fertilizers, climate change and the need to augment the sources of nutrients will however drive the application of these organic and local materials in smallholder farming systems. Smallholder farmers have knowledge of these agronomic practices, nonetheless, training is needed on the timing and application of these practices to create optimal conditions for crop growth. Smallholder farmers apply manure for its soil and crop nutrient augmentation purposes. Mulching is also applied to maintain soil moisture and the supply of nutrients. While these agronomic practices are technical, in smallholder systems, a great deal of social organization and negotiation occurs for farmers to successfully implement these practices.

Keywords: social practice, soil, fertility, manure, mulch, smallholder, yield, crop, nutrition, agronomic practices, farmers

Funded by: Mohammed VI Polytechnic University, Morocco

A multi-actor approach to embedding soil sustainability into local planning policy

By Jess Davies, John Quinton, and Mirian Calvo

Lancaster University

Soil degradation and loss due to urban development and construction activities is a significant and often overlooked environmental challenge. Despite urban areas occupying a relatively small portion of the global land resource, the impact of construction on soil health is disproportionately large. For example, in the UK in 2018, 29.5 million tonnes of soil from construction sites was disposed of in landfill – approximately 10 times that estimated to have been lost from agricultural lands across England and Wales by erosion. In addition to soil loss, compaction, poor stockpiling practices, and contamination have effects on soil organic carbon, biodiversity and water infiltration with consequences in the long-term for flood risk, green space quality, and other important ecosystem services delivered by urban soils (O'Riordan et al, 2021).

As the demand for housing and urban expansion grows in the UK, it becomes increasingly important to protect and enhance soil resources during construction. Achieving this requires a collaborative effort across multiple sectors. The complexity of development, involving various stages, industries, regulations, and stakeholders, presents both challenges and opportunities for integrating soil sustainability into practice.

In an on-going interdisciplinary project combining soil science with participatory design and architecture, we have been addressing these challenges. By working closely with local authorities, planners, landscape architects, contractors, regulators, environmental groups, and waste companies, the Local Soils project seeks to embed soil sustainability into local planning policies. These policies are key leverage points that influence how developments are conceptualised, designed, constructed, and monitored.

Here, we will present the outcomes of a series of cross-sector focus groups and workshops aimed at integrating soil sustainability into planning and construction and share progress towards a model policy that prioritises soil health, helping to create better, more sustainable places to live and work.

Keywords: construction; planning policy; interdisciplinary; participatory; soil health

Funded by: EPSRC and AHRC IAA; Lancaster City Council; Cornwall Council

My Soil Mates: a collaborative project to raise the profile of soil biodiversity in schools

By Katie Somerville-Hall, Tammy Edmonds-Tibbett, and Pablo Homet-Gutierrez

University of Reading

The My Soil Mates project aimed to raise awareness among school students about the importance of preserving soil biodiversity, and provide them with the understanding needed to appreciate and protect it. This was done via in-person sessions in four high schools (two in the UK and two in Spain), reaching 189 students aged 10-16. We also created an educational brochure containing an outline of the role of soil fauna in decomposition, a soil fauna ID guide and instructions for the experiments. In four sessions, students were introduced to the process of soil decomposition, the main soil meso- and macro-faunal groups, and the importance of maintaining their biodiversity. The students then took part in two experiments. In the first, they buried five organic and inorganic materials with varying decomposability in different ecosystem types in the school grounds and measured mass loss after three months. In the second experiment, they extracted mesofauna from soil samples using Berlese funnels, identified them, and compared faunal richness and abundance between ecosystem types. The students recorded their experimental data and completed questionnaires to evaluate learning outcomes. We closed the project with a final presentation of the results and conclusions, including a class discussion about the relationships between soil faunal diversity, decomposition rates, and ecosystem types. By the end of the project, students were able to recognize the importance of biodiversity for maintaining ecosystem functions, (decomposition as a component of nutrient cycling essential for food production) and the consequences of biodiversity loss for the planet and humanity. My Soil Mates was a collaborative project between the University of Reading, UK, and the Universities of Seville and Cádiz, Spain. The brochure is available from the BSSS website (https://soils.org.uk/education/educational-materials). An X (Twitter) account was set up to share the project: @MySoilMates

Keywords: soil fauna, decomposition, biodiversity, soil ecology, education

Funded by: British Society of Soil Science and Spanish Society of Soil Science through the 75th Anniversary Joint Grant for Promoting Soil Science

Link to Poster

Efforts to Increase Soil Literacy: A case study of two EU Mission soil projects

By Karolina Trdlicova, and Emma McKenna

James Hutton Institute

Using the example of two projects funded under the EU Missions 'A Soil Deal for Europe' LOESS (Literacy Boost through an Operational Educational Ecosystem of Societal Actors on Soil Health) and ECHO (Engaging Citizens in Soil Science: The Road to Healthier Soils) our poster's aim is to illustrate the different ways in which increasing soil literacy and soil education is facilitated within these projects and to invite participation from conference attendees. Taking the view that increasing soil literacy and engaging citizens in soil stewardship is paramount in maintaining future soil health, our poster will present the comparison of the approaches taken, whilst also emphasising the need to go beyond sharing knowledge. We argue that to maintain soil health it is important to foster behavioral change among citizens and to motivate them to protect and restore soils by re-establishing their relationships with soil. LOESS is a project which is largely focused on developing educational offers and continuous training programs as well as skills development activities addressing multiple actors, stakeholders and target groups connected to soil education. ECHO aims to engage citizens in protecting and restoring soils by building their skills and enhancing their knowledge on soils with citizens also actively contributing to the project's soil data collection. Both projects therefore share the aims of engaging with citizens albeit in different ways. By comparing the approaches applied to citizen engagement and increasing effective soil knowledge flows, we aim to enhance awareness of our projects amongst UK citizens who are interested in soil health, provide useful perspectives for future soil health projects as well as make the case for a citizen-centered approach to soil stewardship.

Keywords: Citizen Science, Citizen Engagement, Soil Education, Soil Literacy

Funded by: UKRI, European Union, The James Hutton Institute, Queen's University Belfast

Link to Poster

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Regenerative agriculture improves productivity, profitability, and carbon footprint

By Albert Muleke[2], Karen Christie-Whitehead[1], Michelle Cain[2], Paul Burgess[3], Katy Wiltshire[2], Georgios Pexas[2] and Matthew Tom Harrison[1*]
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The broad philosophy comprising regenerative agriculture can be deconstructed into several underpinning principles, including cell grazing, improved biodiversity, silvopasture, absence of cultivation, synthetic fertiliser and pesticide use, and high soil organic carbon (SOC) stocks. Here, we use sheep case study farms positioned across a rainfall gradient in southern Australia to examine how pasture species diversity, antecedent SOC and cell grazing influence SOC, greenhouse gas (GHG) emissions, pasture production and enterprise profit. Compared with light grazing intensities for long durations, high-intensity short duration cell grazing with long spelling periods (adaptive grazing management) amplified pasture productivity, improving SOC accrual and GHG abatement, enabling greater profit per animal ($10/dry sheep equivalent; DSE) and farm area ($74/ha). Integration of high-yielding, low-emissions ecotypes into swards (such as subterranean clover) enhanced pasture production and improved carbon removals, albeit to a lesser extent than that realised from cell grazing. Adaptive grazing management, where animals were moved in response to seasonal conditions and pasture residual, evoked the greatest SOC accrual and GHG abatement, but also increased supplementary feed costs, and reduced profit per hectare and per animal ($210/ha and $21/DSE respectively). Low stocking rates with longer spelling periods between grazing events were most profitable, highlighting the need to adapt stocking rates and grazing management to not only seasonal conditions but also long-term carrying capacity dictated by climate and soil characteristics. Pasture ecotypes with lower productivity subjected to high intensity grazing and long rest periods were the least economically viable and had the highest net GHG emissions. We conclude that (1) whole farm stocking rate and annual rainfall quantum have greater influence on pasture production, SOC stocks, GHG emissions and profitability compared with species diversity and grazing management, (2) individual pasture species, rather than species diversity have greater bearing on sward production and (3) adaptive grazing management – which typifies regenerative agriculture – can catalyse SOC accrual, carbon removals and sward production compared with lighter stocking for longer durations, provided whole farm stocking rate is in harmony with long-term sustainable carrying capacity, which is dictated by agroclimatic context.

Keywords: Regenerative agriculture, biodiversity, soil carbon, natural capital, prosperity, mitigation, ecosystems services, adaptation, drought

Funders: The Australian Wool Innovation Limited (AWI)

Biogeochemical determinants of carbon accrual in restored peatlands

By Ashish Malik, William Pallier and Claire McNamee

University of Edinburgh

Carbon dense peatland ecosystems have been drained or mined leading to carbon loss driven in large part by microbial decomposers. Peatland restoration can halt carbon losses and even potentially return accrual, and associated climate benefits. To better plan and manage restoration we need to gain a mechanistic understanding of the biogeochemical processes of carbon cycling in peatlands and how microbial systems recover following damage. We sampled seven UK peatland sites, each containing near-natural, degraded, and restored areas and performed microbial functional trait analysis using metagenomics and stable isotope labelling. Microbial traits were linked to vegetation composition, peat organic matter chemistry and other environmental characteristics to determine the key factors that influence carbon accrual. We also assessed the resilience of near-natural, degraded, and restored peatlands to simulated water-table drawdowns in intact peat core mesocosms by measuring changes in CO2 and CH4 fluxes. The results indicate only a partial recovery of environmental characteristics and microbial functioning in restored peatlands when compared to near-natural peatlands. Restored peatlands were also less resilient to short term water-table drawdown with increased greenhouse gas fluxes post rewetting. We observed that anoxic conditions in near-natural peatlands lead to microbes utilising alterative electron acceptors that yield lower energy and limit growth and decomposition causing carbon accumulation. Drainage removes these constraints due to increased observed oxygen availability as electron acceptor; we also observed increased abundance of genes for complex substrate breakdown. Restoration brings back these constraints thereby lowering the growth rates. We also demonstrate that oxygen is more important than vegetation type and organic matter chemistry is determining rates of microbial processes. These results demonstrate that the restoration of a high water-table, and the resulting anoxic conditions and signature peat bog vegetation are key to restoring microbial functioning to a near-natural state to bring back carbon sequestration in peatlands.

Funders: Natural Environment Research Council

Regenerative agricultural practices and soil carbon: current findings from a new long-term experiment

By Jonah Prout[1], Felipe A. Torrentí[2], Kevin Coleman[1], Stephan M. Haefele[3], Marcelo Galdos[4], Andrew Mead[2], Jonathan Storkey[5]

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Soil organic carbon (SOC) is a key indicator and driver of soil health. As farming practices and management change to increase sustainability, the impact of such changes on soils needs to be studied. The Large-Scale Rotation Experiment (LSRE) is a relatively new experiment from Rothamsted Research taking a multidisciplinary approach to questions around agricultural production, and environmental and economic sustainability. It was started in 2017/2018 at the Broom's Barn (sandy loam) and Harpenden (silty clay loam) sites. The design of the experiment, and treatments of crop rotation, tillage practice, crop protection, and organic amendment, allows for the assessment of the impacts of different agricultural priorities. At this time, the data from two samplings have been analysed allowing us to see an indication of the effects of the different treatments on changes in soil organic carbon (SOC). Early exploration suggested an impact of tillage and organic amendments between baseline and sampling after 3 years as might be expected. Here we present a more complete comparison of SOC across sites, treatments, and soil depths (down to 1 m). The organic amendment treatment is applied at certain points in the rotations (rotation phase), so we expect that there may be an interaction due to incomplete rotations and time since amendment. The smart crop protection treatment includes the use of companion cropping, cultivar mixtures and differences in pest and weed management which may also have detectable impact on SOC accumulation as the experiment continues. These results will help (alongside other aspects of the experiment) to understand trade-offs and optimise management as farming and land management look to a more sustainable future.

Keywords: soil organic carbon, regenerative agriculture, tillage, organic amendment, crop rotation."

Funders: BBSRC

Microbial bioinoculants obtained from pristine grassland can build soil organic carbon in cropland soil

By Lisa Cole, Ashish Malik

University of Aberdeen

Agricultural intensification leads to loss of soil organic carbon (SOC) that compromises soil health and contributes to greenhouse gas emissions from land. Restoring belowground SOC offers an opportunity to help mitigate climate change and promote soil health. The soil microbiome is responsible for transforming plant materials that enter soil into stable forms of SOC, and the microbiome of pristine grassland soils especially supports this process due to its high carbon use efficiency. This suggests that grassland microbiomes could be recruited to help restore SOC in degraded soils. To examine this theory, we established a mesocosm study where we reciprocally transferred microbiomes derived from historically undisturbed grassland soil and neighbouring cropland soil into their sterile counterparts, collected at two UK sites. We examined microbial biomass and community assemblage of the introduced microbiome in soils over 8 months. We also monitored soil C partitioning as respiration throughout the study and as SOC at the end of the study. We observed that soil conditions selected for distinct bacterial communities irrespective of the initial introduced microbiome, suggesting that ultimately, communities became filtered by soil properties. While this raises questions around the persistence and therefore efficacy of microbial inoculations for soil recovery, our study highlights the need for careful land management to promote beneficial microbiomes with high functionality for sustainable soils. We also observed that a grassland-derived microbiome led to positive outcomes in terms of SOC changes in cropland soil after 8 months, supporting the notion that soil microbial inoculants can benefit environmental restoration. We conclude that bioinoculants could be leveraged to help soils sequester carbon, so long as soil management promotes biodiversity with traits that support soil carbon stabilisation processes to achieve healthy, sustainable soils.

Funders: NERC funded Daphne Jackson Trust Fellowship

Designing a soil health index for sustainable agricultural systems

By Munisath Khandoker, Stephan Haefele and Andrew Gregory

DEFRA and Rothamsted Research

"Healthy soil acts as a reservoir and cycling system for nutrients essential for crop growth and hosts a diverse range of organisms, including bacteria, fungi, insects, and worms, contributing towards ecosystem stability and resilience. However, soil health cannot be directly measured. Instead, soil health assessments typically rely on a range of measurements from essential biological, physical, and chemical indicators. But due to the highly integrative nature of soil, it is difficult to develop general soil health indices.

Structural equation modelling (SEM) is one method to address the challenges associated with characterising soil health. It works by developing a structural model that outlines the relationships between different components of soil health, including physical, chemical, and biological indicators, and defining how each variable influences or is influenced by other variables.

Using Rothamsted Research's long-term experiments in the UK, we took measurements from essential soil health indicators with the aim of using SEM to design a soil health metric that can describe soil health across different land management and soil types. Overall, we found SEM allows for a comprehensive understanding of observed indicators and latent variables that contribute to overall soil health. However, our proposed model proved to be unsuitable for application across all soil types and land management practices. Instead, its effectiveness was most apparent when applied to specific land uses and soil types; however, larger sample sizes are necessary to gain a comprehensive understanding. Nonetheless, based on our results, we believe soil scientists can leverage SEM to refine soil health assessment models and improve the accuracy of their measurements, as well as understand the effects of agricultural management practices on soil health."that support soil carbon stabilisation processes to achieve healthy, sustainable soils.

Funders: Rothamsted Research

The economic impacts of soil degradation on Scotland's water environment

By Nikki Baggaley, Fiona Fraser and Paul Hallet

James Hutton Institute

"Using a combined biophysical and economic assessment, we have estimated that soil compaction in Scotland costs between £16 million and £49 million per year. The extent of soil compaction in cultivated land was based on measurements of air capacity from four post-2007 datasets including the National Soil Inventory of Scotland (NSIS2007-09). Using these data we estimated that 56% of the land most at risk of compaction, 21% of land at a moderate and 12% of land at low risk was compacted. From this we modelled the impact on crop yield, using spring barley as an example, by altering of the amount of water held in a compacted soils in a crop model. We estimated a yield loss of 109,000–324,000 tonnes, depending on the proportion of land compacted. On top of this cost of additional fuel use added £9-26 million at the farm gate.

Our economic assessment also considered the extent, impact and costs of other forms of soil degradation in Scotland including soil sealing. The extent of soil sealing was estimated from Ordnance Survey MasterMap® data and combined with the estimates of the extent of soil compaction in cultivated land. Increases in runoff and hence flood risk, were estimated by altering the HOST Standard Percentage Runoff (SPR) in proportion to the decrease in soil porosity due to compaction and sealing. In a catchment with an increase in sealed area of 1%, SPR was increased by 1.5% and in a series of example catchments additional SPR from compaction ranged from 0.8 to 7.8% depending on the proportion of cultivated land that was compacted.

Clearly soil degradation can result in considerable costs both at the farm gate and more widely. Going forward, economic costs need greater assessment alongside measurements of soil degradation to obtain more robust estimates.

Keywords: Soil degradation, Economic assessment

Funders: Scottish Government

Modified Spent Coffee Grounds (SCG) and Biochar remediation of heavy metal contaminated urban soils in Glasgow

By Prudence W Mhlophe

University of Glasgow

"Heavy metals contamination is one of the biggest threats for both urban and agricultural soils. Earlier remediation methods were prioritized on efficacy; however, today's innovative approaches are evaluated on sustainability, cost, and multifunctionality. The abundance and therefore, low cost of the waste coffee biomass makes it a great choice for use in soil remediation as it also fits into the waste reuse component of sustainability. The use of coffee grounds for remediation is not new its effectiveness has been demonstrated to date. This research explores whether additional modifications can improve the efficacy, particularly for multi-metal contaminated soils. The goal of this study was to investigate how modification by pyrolysis and oxidation using hydrogen peroxide, could help immobilise heavy metals in multi-contaminated soils. The spent coffee grounds (SCG) were split into three main treatments, raw SCG, SCG Biochar (by pyrolysis at 550°C), and then each of these were modified with hydrogen peroxide to create Raw SCG modified and SCG Char modified. These were applied to 500g of soil in column experiments at rates of 1% and 3% respectively, these were replicated five times and included control columns. The soils and treatment mixtures were allowed to incubate under laboratory conditions at 20°C for 28 days, Leachate was collected every 7 days and analysed for pH, EC, DOC, DIC, ICP-OES. On day 29, Pak choi seeds were planted in the columns and left to grow for 60 days. The collected leachate and the end of experiment soils are currently being analysed and results will be available at time of the presentation. Preliminary indications show an increase in plant size with each modification from the raw SCG, with the biggest plants from the treated columns in the modified biochar treatments.

Keywords: soil contamination, spent coffee, biochar, heavy metals, remediation, circular economy

Funders: James McCune Smith Scholarships and GALLANT, Glasgow

Forest biogeochemical monitoring indicates altered biogeochemical dynamics in rhizosphere of oak trees with Acute Decline symptoms

By Selva Dhandapani, Liz Shaw and Xize Niu

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University of Reading, England, UK.

Acute Oak Decline (AOD) is known to cause rapid decline in tree health in a short span of 3-5 years. However, the interactions between such oak decline and rhizosphere biogeochemical dynamics are not fully understood. We selected three oak trees for each of the three treatments for biogeochemical monitoring: 1. No symptoms (Healthy), 2. AOD & 3. Chronic Oak Decline (COD) symptoms, in Writtle woodlands, Essex, UK. The selected trees were used for quarterly rhizosphere soil sampling (cores to depth of 40 cm), and monthly surface soil (0-10 cm), leaf litter and GHG emissions sampling over a year (2022-23). Soil samples were characterised for their chemical properties, total nutrient content & availability. Leaf litter quantity and chemistry characterised. Rhizosphere microbial communities were characterised using Phospholipid fatty acid analyses. Newly developed state-of-the-art micro-dialysis instrument was used to measure continuous real-time changes in soil nitrate levels between different treatments. Almost all the measured properties showed significant changes with season and depth, indicating a strong temporal and depth effect on forest soil biogeochemical dynamics. Notably macro-nutrient contents of leaf litter were greater in the summer period, which resulted in increased soil nutrient availability in Autumn. This pattern was particularly exaggerated in AOD trees, which had greater nutrient content in litterfall in summer and greater nutrient availability in soil rhizosphere zone in autumn than those of other treatments. We found that AOD rhizosphere have altered microbial communities, decreased CO2 emissions and increased macronutrient availability shown by both laboratory analyses and real time in-situ measurement by micro-dialysis instruments. Taken together, our study shows poor physiological nutrient management by diseased AOD trees shown by greater nutrient concentrations in litter indicating a lack of healthy nutrient resorption, and less active root rhizosphere zone under AOD trees, shown by reduced soil CO2 emissions and increased nutrient availability in rhizosphere.

Keywords: Acute Oak Decline, Temperate forests, Soil health, Soil Greenhouse gas emissions, Soil nutrient dynamics, Soil nitrate, Ecosystem monitoring, Soil microbial communities, Plant-soil interactions, Tree health.

Funders: UK Research and Innovation (UKRI); National Science Foundation (NSF), USA.

Technology and Innovation: Oral Abstracts

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A Novel Biodegradable Decomposition Sensor's Output Correlates with Soil Health Indicators in a Field Study

By John Quinton, Taylor J. Sharpe, Madhur Atreya, Shangshi Liu, Mengyi Gong, Noah Smock, Jessica Davies, Richard D. Bardgett, Jason Neff, Rebecca Killick, Gregory L. Whiting

Lancaster University

Monitoring of the microbiological processes in the soil is important to understand and the impacts of agricultural practices on soil health. Evaluation of microbially-mediated soil processes usually involves manual sampling followed by laboratory analysis, which is costly, time consuming, physically intensive, non-continuous, and offers limited capacity for measuring changes at a high temporal and spatial resolution. Low-cost soil sensors manufactured using printing techniques offer a potential scalable solution to these issues, allowing for high-frequency in-situ measurement of decomposition rates. Here, we tested the use of novel decomposition sensors to complement or replace conventional laboratory measurements for the evaluation of soil processes. Sensors were installed across 44 replicate plots at at the long-term meadow restoration experiment at Colt Park, Yorkshire, covering a range of long-term grassland management practices, including synthetic fertilizer addition, manure addition, mixed seed addition, and red clover planting. Concurrently, microbial biomass and enzymatic activities related to carbon, nitrogen and phosphorus cycling were quantified in each plot using standard laboratory methods. Sensor responses were compared to these conventional soil health measures in several ways to better understand their potential utility: All statistical approaches found positive correlations between the sensor signal and laboratory measurements of microbial biomass carbon, and some approaches found correlations with enzymatic measurements. Our findings demonstrate the potential for the proxy measurement of soil processes in situ using novel printed decomposition sensors, thereby supporting their potential for low-cost, high-resolution temporal and spatial monitoring of soil biological parameters and providing new insights into soil health.

KEYWORDS: environmental monitoring, printed electronics, continuous monitoring, in-situ sensing, precision agriculture, soil biological activity, soil microbiome

Funded by: NERC & USDA

Continuous Monitoring of Soil Carbon Dioxide Emissions Using an Arduino Platform

By Marcus Palmer

UWE & Hartpury University

This study introduces an innovative approach using an Arduino microcontroller equipped with onboard programmable sensors for continuous, real-time in-field monitoring of soil carbon dioxide (CO2) emissions. By minimising soil disturbance and allowing in-situ monitoring, this method aims to provide more precise and reliable data, thereby enhancing our understanding of soil carbon processes and soil health.

To test the application of the Arduino sensor platform, fresh soil samples from six fields at Hartpury University Farm were included in the study. Two arable (Big Catsbury and Little Catsbury), two temporary grass (North and South Dandies) and two permanent grass (Broadfield and Duckfield) fields were studied. The results highlighted significant variability in CO2 concentrations, with high peak concentrations indicating short-term spikes in emissions. For example, a peak of 1362 ppm for permanent grass and data suggested substantial short-term emissions dynamics. The mean CO2 concentration was 1031 ppm for permanent fields, with moderate relative variability (11% coefficient of variation). Arable and temporary grass fields also showed higher peak concentrations and greater differences between peak and average concentrations, implying more susceptibility to intermittent activities or conditions. In contrast, permanent pastures exhibited both high average CO2 levels and high peak CO2 levels, indicating more consistent emissions over time.

Field-specific observations suggest significant and continuous sources of emissions and our technology shows potential for assessing the variability with and between fields that is crucial for optimising field management, maintaining soil health, and developing strategies to mitigate CO2 emissions.

The proposed monitoring approach can be used to detect long-term trends, seasonal variation, and short-term pulses in soil CO2 emissions at a field and farm scale. This innovative technique has the potential to bridge existing knowledge gaps, support the broader research community, and contribute to sustainable soil management practices essential for the future of our society and planet.

Funded by: University of the West of England

Physics Informed Neural Networks (PINNs) potentially transform the landscape of agricultural engineering construction in the future

By Dr. Supriti Pramanik, and Dr. Inoue Junya

Department of Materials and Environmental Science, The University of Tokyo

Designing and maintaining irrigation infrastructure for agricultural engineering in regions prone to soil settlement is a crucial task that requires ensuring that the canals and water distribution systems can withstand subsidence caused by soil settlement, as uneven water distribution and crop stress may result.

Soil settlement prediction plays a significant role in ensuring sustainable infrastructure construction., as it helps to guide effective land management practices and infrastructure design . In today's world, artificial intelligence is extensively utilized for various technological applications. In practical engineering problems, such conditions as the initial distribution of excess pore water pressure, drain length, final vertical strain of soils, and the coefficient of consolidation are often quite uncertain, which makes settlement prediction quite difficult. Deep learning neural network like Physics-Informed Neural Networks (PINNs) provide a promising method to enhance these predictions by combining data-driven learning with physics-based modeling and with very less data by incorporating Mikasa equation as a governing equation. PINNs can accurately predict soil settlement dynamics under various agricultural conditions. This predictive capability supports optimized infrastructure planning, proactive soil conservation strategies, and precise agricultural practices. Such advancements empower farmers and agricultural planners to reduce soil degradation, optimize resource utilization, and promote long-term sustainability in agricultural landscapes.

Based on our findings, the PINNs solution demonstrates a high level of consistency with the analytical approach, indicating that it can serve as a viable alternative for addressing agricultural or geotechnical engineering challenges.

Keywords: Soil settlement prediction, sustainable agriculture, Physics-Informed Neural Networks (PINNs), data-driven modeling, infrastructure design optimization, proactive soil management, precision agriculture, environmental impact mitigation, technology and Innovation , long-term sustainability planning.

Funded by: The University of Tokyo

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Correlation Between Soil Moisture, Spectral Response, and Load Capacity

By Ahmed Elawad Eltayeb Ahmed, Gyorgy Pillinger, and Peter Kiss

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The ability of soil to withstand vertical deformation under normal load, which is an important consideration in Terramechanics studies relating to vehicle performance on different terrains, is determined by its load-bearing capacity. The soil's spectral behaviour, which refers to its interaction with light across various wavelengths through absorption, transmission, or reflection, is closely connected to its physical properties, including moisture content.

This study examines the relationship between soil spectral behaviour and load-bearing capacity, focusing on the soil at different moisture levels. The research investigates how moisture content affects and has connected both soil's spectral characteristics and load-bearing capacity.

The load-bearing capacity was assessed using the Bevameter technique, while the soil's spectral behaviour, particularly in the visible range (400–700 nm), was evaluated using spectrophotometry.

The results suggest that an increase in moisture content leads to a decrease in the load-bearing capacity of soil, which is consistent with the observed reduction in colour reflectance. These findings emphasize the interconnected impact of soil moisture on both its spectral behaviour and load bearing. The experiments were conducted at the Department of Vehicle Technology Laboratory, Hungarian University of Agriculture and Life Sciences (MATE).

The reflectance behaviour of European soils with increasing soil moisture

By Denise Hick, Guy Ziv, and Pippa Chapman

University of Leeds

One of the main factors affecting the reflectance of soil in the solar domain (400-2,500 nm) is soil moisture content. Building on previous studies on American and Australian soils, this study explored the relationship between the reflectance of various European agricultural soils, their soil moisture content and their soil properties using spectroscopy.

The reflectance of 28 soil samples from various locations across Europe was collected using a spectroradiometer in a laboratory setting. Following the addition of a known amount of water to each sample, spectral scans were taken at repeated intervals to capture soil reflectance at different levels of soil moisture, until the soil went back to dry. The laboratory spectra collected were aggregated by soil sample, and the reflectance at each wavelength was plotted against volumetric soil moisture content.

Findings showed that the relationship between soil reflectance and moisture was wavelength-dependent and best represented by a decreasing exponential function, but the rate of exponential decrease varied across soil types.

In order to understand why, the rates of decay were normalised, and a linear regression was fitted between the normalisation factor of each soil sample and several soil properties known to affect soil reflectance (organic carbon, clay, sand, silt, calcium carbonate and iron content). Organic carbon content was found to be the most important factor affecting the soil reflectance-moisture relationship, followed by calcium carbonate and clay content. Finally, a new soil reflectance-moisture model for European agricultural soil was proposed.

Keywords: soil spectroscopy; soil moisture; LUCAS; Europe; cropland; organic carbon; carbonates; clay

Funded by: NERC (SENSE CDT); Field Spectroscopy Facility

Link to Poster

Developing a Soil Spectral Library for England: A Tool for Rapid In-Field Carbon Analysis in Agriculture

By Jessica Underwood, Aidan Keith, and Chris Collins

University of Reading

This study focuses on developing a soil spectral library and prediction model for soil properties e.g. carbon content for England using soil samples from the Countryside Survey and a near infrared spectroscopy scanner. The Neospectra scanner is a simple, field deployable, handheld device which with associated models can predict soil carbon content in situ, offering an accessible tool for rapid soil analysis.

These devices have the potential to monitor soil carbon under changing land management and offer farmers and researchers a rapid assessment tool to monitor soil health. This dynamic approach has multiple benefits over current lab-based methods, as it is rapid, requires little preparation and provides near instant results enabling subsequent action to be undertaken quickly and enhancing user engagement.

Funded by: NERC, Affinity Water

Link to Poster

Improving the functionality of a Soil Erosion Sediment Delivery – Decision Support Tool (SESD-DST) and application to priority surface water catchments in England

By Lisa Donovan

Cranfield University

Context

- Current UK policy encourages water companies and farmers to collaborate and uptake minimum tillage and cover crops to reduce soil erosion's impact on the environment, field productivity, and raw drinking water quality.

Aim and objectives

- The aim of this PhD is to further improve the functionality of the modified Morgan-Morgan-Finney (mMMF) model as a decision support tool for water companies and land managers to target management options to reduce runoff and control soil erosion on farm to improve water quality.

- The objectives are to measure the key catch/cover crop and soil surface roughness parameters, reflect the inter- and intra-annual variability of soil erosion risk, identify flow paths and sediment discharge points, evaluate the model's improvements, and validate its predictions.

Methods

- Crop and soil surface roughness parameters are measured in fields under typical rotations thanks to ArcGIS, Python, and advice from seed suppliers and catchment advisors.

- Crop parameters are obtained using photo analysis, manual measurements in quadrats, and literature values, while the chain method is used to measure soil surface roughness.

- Inter- and intra- annual variability of soil erosion risk will be possible by modifying the mMMF's temporal resolution.

- Incorporating a connectivity module based on a routing function will help identify flow paths and sediment discharge points.

- Critical evaluation and validation of the improved model will be based on water quality and remote sensing data.

Impact/ Future work

- The improved model could be used as a user-friendly tool by land managers, water companies, and the government to monitor soil health and river water quality but also to encourage collaboration between farmers and water companies.

- It could also be tested to predict the impact of catch/cover crops and minimum tillage on soil erosion risk in a wider range of crop rotations.

Funded by: Anglian Water, Severn Trent Water, Southern Water

Link to Poster

Using the SENUS app to collect information and support decision making on farm

By Lynfa Davies, Owain Pugh, and Kevin Fennelly

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Soil is the most valuable natural resource on a farm. Soil health is a priority for the Welsh Government, and with the Sustainable Farming Scheme on the horizon, farmers are keen to understand how technology, including apps, can help them to position their business at the forefront of the industry. A project has been set-up to use the SENUS app to collate information including soil nutrient status, VESS (Visual Estimate of Soil Structure) and earthworm numbers. Information such as detailed soil analysis, combined with ground-truthing field surveys backed up by localised GNSS enabled readings with Geo-tagged photographic evidence were captured using the app. VESS and earthworm counts were undertaken by digging 3 soil pits (20cm x 20cm x 20cm) in each field. The VESS score was recorded for each soil pit together with any comments on compaction, rooting depth and any other observations. Earthworm numbers from each soil pit were counted and the number of adults in the three categories of epigeic, endogeic and anecic recorded.

The information held in the SENUS app can be accessed to aid management decisions. For example, users can see where compaction is present or the impact of different crops on soil structure and worm counts. Continued work post abstract submission will enable us to showcase the link between the role of technology in supporting farmers to make decisions towards improving soil health on the farm. The demonstration of technology use will be relevant to the wider agricultural industry in Wales and beyond, and will aid the demonstration of the role technology plays in data collection and as a decision support tool.

Keywords: soil, soil health, farmers, land management, knowledge exchange, technology, farmer participation, Welsh agriculture, sustainable soils, decision support tools

Funded by Welsh Government with support from SENUS and Farming Connect

Link to Poster (English)

Link to Poster (Welsh)

Soil Nutrient Health Scheme: Developing a national-scale risk map of hydrological source areas.

By Paddy Jack, Taylor Harrison, and Luke Farrow

Agri-Food and Biosciences Institute

In Northern Ireland (NI), the predominant pathway for phosphorus loss from agricultural land to waterbodies is via overland flow from Hydrologically Sensitive Areas (HSAs). This is a consequence of high rainfall, impermeable soils, and undulating topography. In a study across multiple agricultural catchments, previous research found a strong relationship between the proportion of a catchment with high HSA risk on soils above optimum for soil test P, and in-stream P concentrations. The Soil Nutrient Health Scheme (SHNS) develops and extends this approach to all areas of NI, strengthening the knowledge base for decision-making around effective mitigation and management strategy.

HSA maps for the whole country will be produced by 2026, based on 16ppm LiDAR data. This will integrate topographic and soil permeability properties to model runoff risk for all agricultural land, providing individual farms with the baseline information needed to implement on-farm nutrient management planning and to carefully manage areas at greatest risk of phosphorus loss to waterbodies.

We present findings from this research which has, so far, been produced for over 13,000 farm businesses of varying intensity and type, across 6,927 km2 of the southern half of Northern Ireland. In addition, an outline of ongoing research regarding the integration of HSA data with the SNHS's field-scale soil nutrient sampling and analyses is highlighted. The research will develop a GIS-based toolkit for the accurate spatial targeting of diffuse pollution mitigation measures at catchment, field and sub-field scale, as the best approach to reduce phosphorus losses to water based on source control and pathway interception.

Funded by: Department of Agriculture, Environment and Rural Affairs

Link to Poster

Rapid assessment of biochar toxicity using fluorescence spectroscopy and machine learning for sustainable soil amendment

By Raghavan Chinnambedu-Murugesan, Adam El-Aradi, and Daniel Nowakowski

Aston University

Biochar is a promising carbon sequestration and soil enhancement solution with significant potential to advance environmental sustainability. However, concerns about its potential toxicity, primarily due to polycyclic aromatic hydrocarbons (PAHs), pose challenges to product safety and compliance with regulatory standards.

This study proposes a novel and rapid approach to assess biochar toxicity by integrating fluorescence excitation-emission (FLE) spectroscopic mapping with machine learning (ML) algorithms. Biochar samples derived from mixed softwood and wheat straw were produced under two pyrolytic conditions (450°C and 550°C) using an industrial-scale mobile pyrolysis unit with a 100 kg/h processing capacity. To assess biochar toxicity, its potential leachates were extracted in water, and a homogeneous optical-grade solution was prepared through sonication and centrifugation at 7000 rpm. This enabled the detection of dispersed PAHs and other soluble organic compounds.

The FLE spectroscopic method successfully identified distinct excitation-emission spectra for trace PAHs, such as anthracene, pyrene, and polyaromatic acids. A machine learning model incorporating parallel factor analysis (PARAFAC), principal component analysis (PCA), and regression was developed to refine this analysis. This model allowed for precise quantification and classification of toxic leachates, offering a reliable and efficient biochar safety evaluation and standardisation tool. This method also eliminates the need for toxic organic solvents used in conventional biochar toxicity analyses.

This research integrates advanced FLE spectroscopy with machine learning to introduce a cutting-edge, solvent-free method for the rapid assessment of biochar toxicity. The findings pioneer more accurate certification processes, ensuring biochar's safe application as a soil amendment, and contribute to the ongoing efforts to make biochar a viable and sustainable option for agricultural and environmental use.

Keywords: biochar; carbon sequestration; pyrolysis; biochar toxicity; polycyclic aromatic hydrocarbons (PAHs); novel analytical method; Fluorescence excitation-emission spectroscopy (FLE); machine learning (ML); soil amendment; environmental sustainability.

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