The Soil Sentinel

The Soil Sentinel ISSUE 5 – DECEMBER 2023

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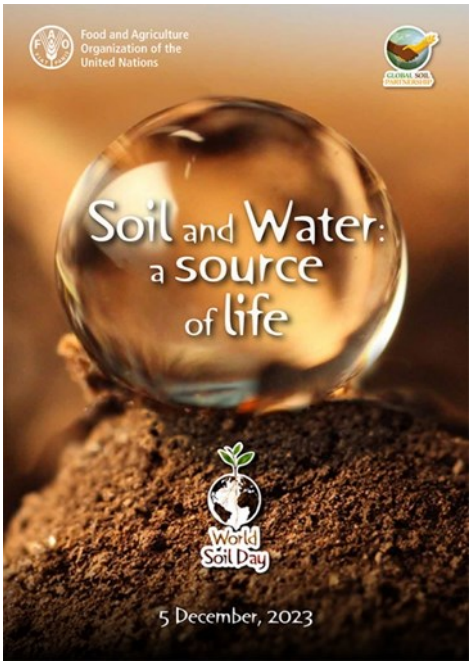
Raising Awareness of Soil Every Year: World Soil Day — Paul Hargreaves (SRUC)

It is encouraging that the United Nations has dedicated a day each year to raise awareness of soils and their importance to life on earth. The 5th of December is that day and this year is no exception. The theme of World Soil Day for 2023 is 'Soil and Water: a source of life'. There are a number of important key messages that are being promoted such as soil and water are the foundation of food production, ecosystems and human well-being. Others include the health of the soil and availability of water are reliant on each other and a healthy soil, rich in organic matter, helps maintain soil moisture levels for sustained crop growth. Research for the UN have calculated that rainfed agriculture accounts for 80 percent of croplands, contributing to 60 percent of the global food production.



Although water coming out of the soil can appear dirty, the soil can act as a filter to help purify the water and can slow the water flow to reduce the effects of flooding. Overall, an impressive list of some of the positives for the relationship between soil and water.

World Soil Day encourages involvement from participants around the world and a map is produced each year to highlight the countries and events involved. This year these have included Hungary with a workshop on crop residues and a painting competition, Spain where a soil themed puzzle room will be set up in the Technological College of Huesca (University of Zaragoza), Morocco (celebration of World Soil Day), Iran where the Agricultural Conservation Network is holding events on farm and Brazil where the University of Campina Grande are launching a children's e-book on the importance of earthworms for the promotion of soil quality. There are over 900 events taking place in Thailand alone as this is the country of the King Bhumibol Adulyade who first proposed World Soil Day and it held every year now on 5th December which was his official birthday. This issue of The Soil Sentinel has been registered as an event and will help promote the Scottish Government's 2022-27 Strategic Research Programme, Healthy Soils for a Green Recovery

There are many useful items available related to World Soil Day to help promote the occasion, such as t-shirts and educational material. The educational items range from posters covering subjects such as soil erosion and minimising erosion from water to comics for children about soil biodiversity. Videos and infographics have been produced explaining the main concepts of soil functions that are also use for education and awareness raising.

Additionally, fun competitions are usually run, which this year included a photo challenge on the theme of 'Soil and water: a source of life', a contest for children to design a poster on the same theme or the task of submitting a children's booklet idea that could win a cash prize. If you have an idea, then think about submitting it for next year's World Soil Day. Last year's winner was a story about a young Kenyan girl and her mother who take a walk and discover different soil types and what soil the plants need to grow. This was based on the theme of 2022 which was 'Soils: where food begins'.

World Soil Day, a great day to celebrate soil health.

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Gorse: unpopular weed or beneficial plant for agroecosystems?—

David Boldrin, Elodie Pascon, Pietro Iannetta, Euan K James, Chrizelle Krynauw, and Kenneth Loades (The James Hutton Institute)

The agricultural ecosystem faces the constant risk of soil degradation, including from the unsustainable use of synthetic nitrogen (N) fertilisers, of which prices have risen significantly (+171% in 2022 for ammonia nitrate). A paradigm shift, from outsourcing and high inputs to 'ecological intensification' (Brooker et al., 2023) is required. Ecological intensification is defined as the enhancement of ecosystem services to complement or substitute for the role of anthropogenic inputs in maintaining or increasing yields (MacLaren et al. 2022; Brooker et al., 2023). Transformation towards ecological intensification requires changing the perception that all non-crop species within the farmed environment are 'weeds' which require removal. In fact, their rapid establishment and synanthropic adaptation make these 'weeds' unexplored resources, and good candidates to provide ecosystem services in disturbed and degrading environments such as intensively farmed (high synthetic input) agroecosystems. For example, woody legumes native to Britain, such as Gorse (*Ulex europaeus* L.), are commonly considered weeds and are actively removed. Gorse is widespread in both natural and anthropic environments, and often considered a ruderal and invasive species by land managers. Consequently, gorse removal is incentivised to clear the land ahead of tree planting for the creation of new woodlands despite the requirement for this being challenged in praxis.

Like many other legumes, the success of gorse in nutrient-poor and highly disturbed soils derives from its root-nodulated symbiosis with nitrogen (N)-fixing soil bacteria collectively termed rhizobia. Indeed, gorse can fix up to 200 kg ha^{1} y^{1} of nitrogen, resulting in fast growth and biomass accumulation (up to 15 t ha^{1} y^{-1} of dry matter). It's capability for Biological N Fixation (BNF), its adaptation to degraded soils, and its fast growth, make gorse a perfect candidate for cost-effective ecological intensification. However, the effect of gorse on soil health and its BNF potential in agroecosystems has not been investigated. Therefore, we decided to evaluate the potential ecosystem services provided by gorse for soil resilience (i.e., response to stresses) and crop performance, with soil samples collected at different distances from established gorse bushes (from beneath the gorse to an adjacent cultivated field).

In the laboratory, soil samples were sieved and tested for aggregate stability in water and recovery after compaction stress (i.e., rebound after loading). Sampled soils were also used to cultivate barley (cv. Sassy, and Bere) and spinach in a glasshouse, and hence assess the effects of gorse (mediated by soil) upon crop-performances (e.g., chlorophyll content). Soil aggregates collected from the centre of gorse bushes showed the greatest stability (→ 90% of aggregates stable in water) (Fig. 1.). In contrast, soil collected from the cultivated field was the most unstable. Soil resilience to compaction stress highlighted similar results. After the application of 200 kPa compaction-stress, which is similar to the trafficking stress exerted by a tractor tyre, soil collected under the gorse showed greater elasticity and recovery (i.e., rebound after loading; Fig. 2). In contrast, field soil showed poor resilience to compaction stress. Soil from field margins (i.e., between gorse bushes and the cultivated field) had intermediate recovery values when compared to gorse and field soils. Greater soil resilience to water erosion (aggregate stability) and compaction (soil recovery after loading) can be explained by the effect of gorse on soil structure and on the continuous input of organic matter through leaf litter and other root-mediated processes. Indeed, soil under the gorse had the greatest C content (up to 9%). In addition to the positive effects on soil health, we also found a positive effect on crop health. Barley and spinach plants growing in soil collected close to the gorse had greater chlorophyll content. This positive effect can be explained by the greater N concentration in the soil close to the gorse due to its BNF (e.g., up to three-fold greater N compared to adjacent soil).

In conclusion, gorse can have positive effects on both soil and crop health, and its utility for field shelterbelt and agroforestry needs consideration and further research. Our results also suggest that it may be counterproductive to incentivise gorse removal to create new woodland as notable ecosystem services and C-stocks might be lost with gorse removal as previously highlighted in the case of tree planting on organic soils (Friggens et al. 2020).

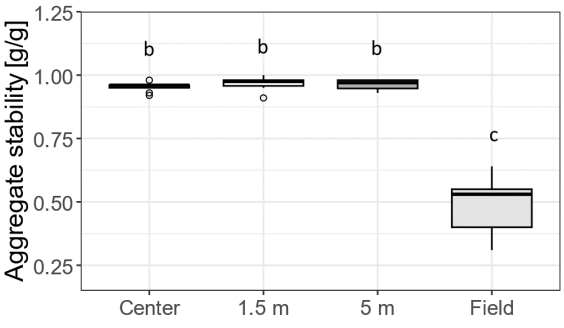

Fig. 1. *Aggregate stability in water for soil sampled at different distances from gorse bushes. "Center": soil from the centre of gorse bushes; "1.5 m" and "5 m": soil collected at 1.5 and 5 m distance from the centre of a gorse bush; "Field": soil collected from the cultivated field. Letters indicate statistical differences tested by ANOVA.*

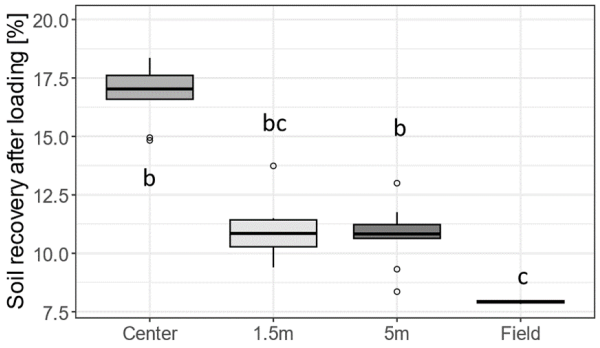

Fig. 2. *Soil recovery (i.e., rebound) after compaction stresses (200 kPa). "Centre" soil from the centre of gorse bushes; "1.5 m" and "5 m" soil collected at 1.5 and 5 m distance from the centre of gorse bush; "Field" soil collected from the cultivated field. Letters indicate statistical differences tested by ANOVA..*

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Can precision liming of grasslands mitigate nitrous oxide emissions?

- Stephanie Jones, Bob Rees, Joanna Cloy, John Parker, John Holland (SRUC), Ute Skiba, Nick Cowan (CEH) and Madeline Giles (The James Hutton Institute)

Agricultural soils are the largest anthropogenic source of the potent greenhouse gas nitrous oxide (N_2O). Hence, there is much interest in a systematic evaluation of management options to minimize agricultural N_2O emissions.

The two mechanisms principally responsible for N_2O emissions from soils are microbial nitrification (oxidation of ammonium to nitrate) and denitrification (reduction of nitrate to atmospheric di-nitrogen N_2) processes, which are influenced by soil environmental conditions, soil C and N inputs. There is evidence, stemming mainly from laboratory experiments, that at low soil pH the final step in denitrification, the reduction of N_2O to N_2, is inhibited, leading to increased N_2O production. Therefore, an increase in soil pH will support the transformation of N_2O to climate-neutral N_2 and thus might mitigate N_2O emissions.

Fig. 1. Easterbush pH plots with static chambers.

Intensively managed temperate grazed grassland soils tend to be acidic, caused by a combination of high rainfall/low evapotranspiration and acidifying nitrogen from fertilisers and animal excretion. Thus, increasing soil pH by lime application might be a way to reduce N_2O emissions. Liming can also offer benefits in terms of increasing plant available phosphorus, increasing plant biomass production and enhancing carbon sequestration. Grassland exhibit a high degree of spatial variability of soil conditions, including pH, at the field scale. In order to optimise the benefit of liming, the use of precision liming, where lime is applied at a variable rate depending on the local pH, will optimise productivity, increase profitability and might lead to better environmental outcomes.

Fig. 2. Kirkton pH plots with exclusion cages

The aim of this study was to investigate the influence of precision liming on N_2O emissions from intensively and extensively managed grassland. Two separate liming experiments were carried out, one on an intensively managed grassland, which was cut for silage at Easter Bush, near Edinburgh (2017-2018) (Fig. 1.), and one on a set stocked permanent pasture at Kirkton Big Meadow (Fig. 2.), at the SRUC Hill and Mountain Research Centre Farm (2019-2020). A soil pH map was produced for both fields, showing a high pH variability ranging from 5.4-6.9, with an average soil pH of 6.1 per field. Both experiments were established in the most acidic area of the fields and two liming strategies with a target pH of 6.4 were applied. The first strategy represented a conventional lime application based on the average soil pH of the field, the other represented a precision liming application, based on the actual soil pH of the plot area, while control plots did not receive lime. N_2O fluxes were measured weekly and more frequently after fertilizer events by a closed chamber method, while soil parameters and plant productivity were measured monthly.

Daily N_2O fluxes were low at the Easter Bush site (max. emissions of 38 g N_2O-N ha^{-1} d^{-1}) due to dry conditions, while at Kirkton high N_2O emissions, with peaks up to 85 g N_2O-N ha^{-1} d^{-1}, occurred after N applications, where rainfall was higher. Lime applications increased soil pH at both sites over the two years. However, we did not see a mitigation in N_2O fluxes nor an increase in yield from either liming strategy at either site. Furthermore, we could not find a correlation between soil pH and N_2O fluxes. The lack of a significant liming effect seen in our study was possibly due to too small soil pH differences between treatments and a high spatial variability of N_2O fluxes. Based on our findings, this study does not provide evidence in support of liming as a mitigation option for greenhouse gas emissions and increased yields.

For further information please contact Dr Stephanie Jones (stephanie.jones@sruc.ac.uk)

Fig. 3. *Kirkton pH plots with static chambers*

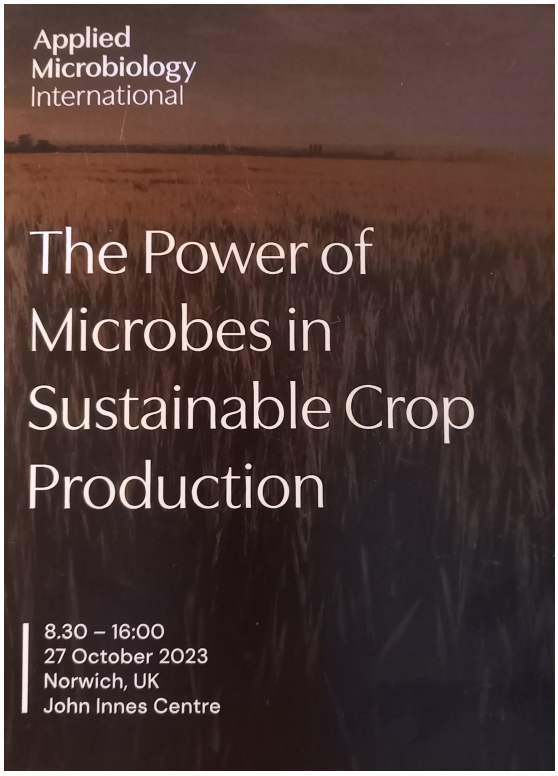
The Power of Microbes in Sustainable Crop Production: Meeting Report — Nicola Holden and Christine Watson (SRUC)

For microbiologists, it is obvious that microbes hold many of the solutions to, and indeed still cause many problems of, our global challenges. However, it is much less obvious to others, and this can lead to serious knowledge or evidence gaps.

The UN Sustainable Development Goals act as a focal point for global grand challenges. UN SDG 2, Zero Hunger is most relevant to food security, to provide a sufficient supply of food that is safe and nutritious. Together with the Applied Microbiology International society, Healthy Soils project members wanted to spark the conversation on sustainable crop production as one of the key topics in food security.

Crop production in underpinned by soil functions, with impacts on crop productivity and resilience against disease. The challenge of climatic change pervades every aspect of production and is itself a major driver for change.

An AMI-led workshop chaired by N. Holden (SRUC, Healthy Soils), brought these aspects together to understand how taking an applied microbiology approach could contribute (Oct 27th, John Innes Centre, Norwich).



Yvonne Pinto (Eagle Genomics) set the scene examining the promise and some of the hype around the soil microbiota. A key point was around the soil seeding the plant microbiota, and the potential of enhancing plant-microbe interactions. Thomas Bell (Imperial) focused on two examples of perturbations to the microbiota and their impact. These gave insights into the unpredictable consequences that can arise, and the 'tipping' points that affect community composition response. Fiona Brennan (Teagasc) told us about the changing face of agricultural systems. She raised the major factors around heterogeneity in the soil microbiota and food webs, with the fundamental requirement to consider ecological interactions. She also warned against over-promising to the end-user groups. Leo van Overbeek (Wageningen) examined risks from the unintended consequences of circular agricultural practices that can introduce human pathogens or antibiotic resistance into crop production. His presentation picked up the common themes of cross-stress protection, and ecological interactions, with the need for knowledge of the indigenous communities.

With this fresh in mind, we moved to the discussion session. Christine Watson (SRUC, D3 Health Soils) was one of the chairs, along with Ashish Malik (Aberdeen) who set the scene for the two areas of focus, Soil Health, and Resilience to the effect of Climate Change. Christine showcased the need for long-term experimental cropping platforms, while Ashish raised the need for an integrated ecological approach. Both sets of discussions focused on environmental conditions, with lots of reference to the recent flooding events in the UK (storm Babette) and the impacts on primary production systems.

Our conclusion was that there are still many unknowns for effective application of microbes in crop production, and in our understanding of how the systems impact the microbes. Nonetheless, some actions can be taken now. These include a full consideration of microbes and microbiology in crop production systems, especially in light of climatic change or the farming practices to mitigate it. The D3 Health Soils project together with sister projects on soil microbiomes provides the ideal platform to take our current knowledge to the practitioners and end-users. This needs to be a two-way dialogue to keep expectations realistic, and to understand the key drivers.

For further information please contact Professor Nicola Holden (SRUC) (Nicola.Holden@sruc.ac.uk)and Professor Christine Watson (SRUC) (Christine.Watson@sruc.ac.uk)

Propagating young minds to take root about the importance of soil—Gemma Higgins (SRUC)

It goes without saying that agriculture students must understand soil principles and management in order to maximise business profits and ensure sustainable farming practices in the future.

Soils within SRUC agriculture courses

Soil concepts and management have been an integral part of agriculture courses for years. Field and lab practical activities such as soil structure and texturing determination, soil sampling, pH and nutrient tests have helped students to engage with and understand concepts taught in the classroom, particularly at Scottish Vocational Qualification (SVQ), National Certificate (NC), Higher National Certificate (HNC) and Higher National Diploma (HND) levels.

SRUC agriculture courses are currently undergoing a number of changes. This brings the opportunity to take a different, more modern approach to teaching soil topics and include any aspects previously missing. The HNC and HND are part of the SQAs Next Generation Higher National (Next Gen: HN) pilot scheme which has several objectives including courses to have fewer but larger units, reduced assessment load and be digital by design. Students must now engage with United Nation Sustainable Development Goals (SDGs) and soil management is key to achieve multiple SDGs.

Previously soils was taught as a standalone unit but it is now integrated within the crop and livestock units which is giving a more holistic and joined up approach when con-

sidering soils on farms. The HNC NextGen course was launched in the 2022-23 academic year and students must show their knowledge of not only physical soil characteristics but also soil chemistry and biology. They need to consider how these characteristics influence production systems as well as the impacts crop and livestock production has on soils such as erosion risks and effects on biodiversity.

The HND NextGen course is running for the first time this academic year. Students are building on their previous knowledge of soils plus considering regenerative farming techniques. One part of the course requires students to carry out their own small scale research project and some students have chosen to investigate how soil characteristics impact crop productivity e.g. how different soil textures and levels of compaction effects germination and crop growth.

It is not only the HNC and HND courses being revamped, the degree programme is also being revalidated and will start in the academic year 2024-25. The unit descriptors

are not yet finalised however, it is intended that students will gain a deeper understanding of soils as well as get the opportunity to evaluate and analyse topical issues regarding soils. There will be a focus on technology with topics such as remote sensing and precision technology for assessing and managing soils to benefit soil health to be covered.

There is also a new Technical Apprenticeship in Agricultural Management. The course is primarily aimed at those wanting to achieve a HND level qualification but not wishing to study full-time and will include soil topics holistically as part of grass and forage subjects.

Students get involved with RESAS and research

Recently Barony NC Agriculture students have been getting involved with a multi-species sward trial as part of the current RESAS Greenhouse Gas work package. They assisted with the marking out, sowing and harvesting of the plots. This not only gave students practical research skills but gave them an insight into different career options they may not have considered. This multi-species trial has been a fantastic teaching resource as students can be shown how to identify different species, some of which they never have heard of before, and discuss the production and environmental benefits. These plots even featured in the 23/24 induction week scavenger hunt!

There have also been other opportunities for research to be incorporated with teaching. Paul Hargreaves has delivered sessions to 3rd year degree students on the latest research in soil carbon sequestration and features previous RESAS work on controlled traffic farming (CTF) in grassland scenarios.

It is hoped that students can continue to be informed about current research and that opportunities for them to be involved practically with trials will arise again in the future.

For more information about SQA NextGen visit NextGen: HN - our qualifications are changing - SQA,

SRUC agriculture courses visit Agriculture \| SRUC or contact Gemma Higgins (Gemma.Higgins@sruc.ac.uk)

Diageo launches Scotch whisky regenerative agriculture programme in Scotland — Kenneth Loades (The James Hutton Institute) and Adam Carson (Diageo)

A three year programme has been launched in Scotland by Diageo to take a science-based approach to investigate regenerative agriculture. The project is working closely with the James Hutton Institute, Agricarbon, Scottish Agronomy, and SAC Consulting to build long-term resilience into Diageo's supply chain.

Regenerative agriculture is a holistic approach to farming that works in harmony with the natural environment. It uses the best agricultural advice to produce crops, while also, delivering beneficial outcomes for soil health, climate, water and nature.

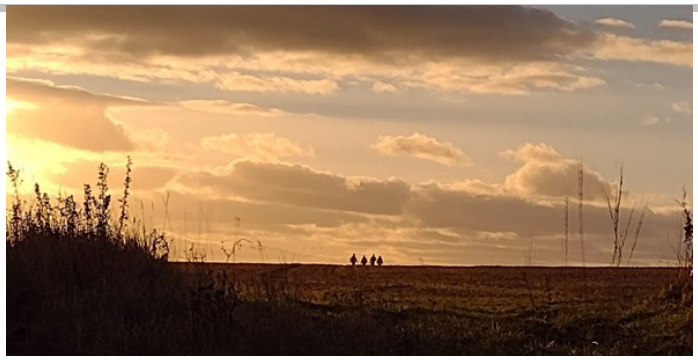
From the James Hutton Institutes science and research perspective it's exciting to be working alongside Diageo in this programme to understand the importance of soil health and the role that innovative farm management can play in securing it. This project offers a fantastic opportunity for the whole value chain including processors, farmers, and scientists to understand current soil health on the journey towards addressing the global challenges facing soils and the wider environment. Vanessa Maire (Diageo Global Head of Regenerative Agriculture) commented at launch that "we look forward to working with stakeholders across Scotland to help build resilience across farming systems and ensure long-term availability of quality barley and wheat by using regenerative techniques, to ultimately achieve our common goal of building a sustainable future for our industry." The long-term availability of quality barley and wheat is essential to the production of Scotch whisky. Using more regenerative techniques to grow these crops will help build supply resilience in the face of a changing climate and help to protect the sourcing landscapes for Diageo's iconic brands in Scotland.

Working closely with The James Hutton Institute and two of Scotland's largest independent providers of agricultural and sustainability advice, Scottish Agronomy and SAC Consulting, the programme will focus on two areas. Firstly, the programme will aim to work with approximately 20 farms in key barley and wheat sourcing regions across Scotland for Diageo. The farms will be recruited into groups, from the Scottish borders to the north, where they can work closely with the programme's technical partners, share learnings, and together advance locally suitable regenerative agricultural interventions. Secondly, the programme will also commission plot scale research trials, to ensure the overall approach is science led, so that findings can be shared with confidence with the wider industry.

Scottish Government funded research on soil health has enabled the skills and knowledge needed to work alongside global companies on their journey towards a sustainable future. It is not

just an exciting time for science and research but also for the agriculture industry. Duncan Wilson, one of the farmers involved in the project, is fully supportive of the work, "We know that healthy soils are the foundation of our farm business and that's why we've been testing different methods over the last decade to improve soil health and reduce our reliance on costly inputs. We are excited to be involved in this project and work with leading scientists and other farmers to find new solutions that work for our business and the environment.".

For more information please contact Dr Kenneth Loades (kenneth.loades@hutton.ac.uk).

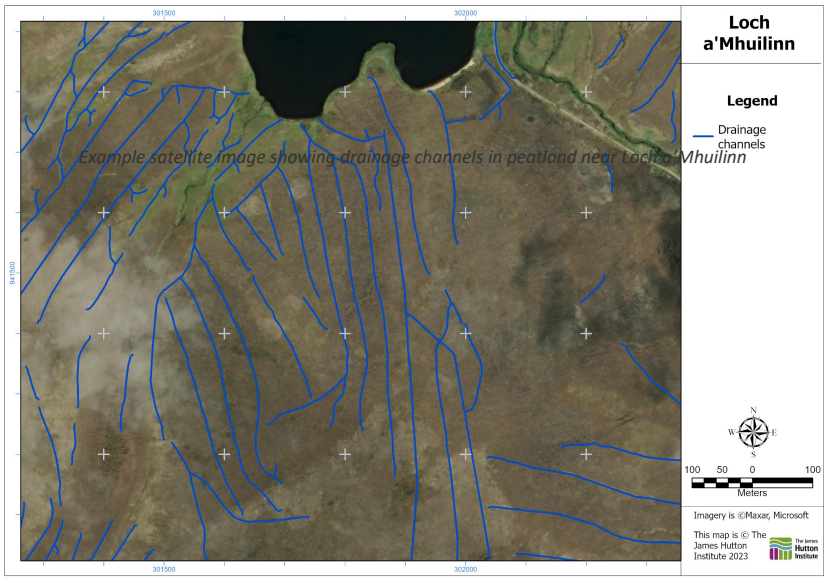


CentrePeat update — Fraser Macfarlane, Linda Toca, Ciaran Robb, Margaret McKeen (image), Alessandro Gimona, Matt Aitkenhead and Rebekka Artz. (The James Hutton Institute)

The CentrePeat project, funded by the umbrella of the current Strategic Research Programme, aims to inform the protection and restoration of peatlands across Scotland.

In this article we focus on the advances made within one of the five technical work packages of this 5-year programme. In WP2 of this project, we aim to provide a nationally coherent geospatial output of peatland condition across Scotland, in a way that is compatible with the way peatland condition is considered within the UK National Atmospheric Emissions Inventory (UK Greenhouse Gas Inventory) and biodiversity reporting requirements. The methodologies developed within this WP will also pave the way for consistent national monitoring of the impacts of land management decisions, including the monitoring of peatland rewetting efforts, and of the impacts of climate change.

Peat soils (organic soils of →50 cm depth) make up 25-28% of Scotland's soils and are critical in many areas, including biodiversity and habitat support, water management, and carbon sequestration. The latter is only possible in healthy, undisturbed peatland habitats where the water table is sufficiently high and stable. Previous work on mapping peat depth and condition in Scotland has provided maps with reasonable accuracy at 100 metre resolution and has allowed land managers and policymakers to both plan and manage these soils and work towards identifying priority sites for restoration. The spatial variability of peat depth and surface condition can be very high, particularly in drained or eroded upland areas and in highly fragmented lowland peatlands, limiting our ability to develop skilful site prioritisations or site-specific restoration plans. Similarly, the current peatland condition map used within the UK National Atmospheric Emissions Inventory has high spatial uncertainties that limit the ability to develop national policy on land management options on peat soils.



Efforts to update peatland depth and condition mapping to 10 metre resolution have been undertaken within this project, using high resolution aerial and satellite imagery. The peat depth and soil property modelling indicate the quantity of peat in any given location, indicating both the spatial extent of a peatland and its carbon stock. The high resolution (25 cm) condition mapping based on aerial imagery allows for the assessment and quantification of any potential degradation, and resultant carbon emissions. This higher spatial resolution, national scale mapping, which has been carried out allows for a deeper understanding of Scotland's peatlands and will enable various scientists, stakeholders, and policymakers to make informed decisions over the protection and restoration of this vital resource. At the present time, this data product has been completed but still requires external validation.

Hutton scientists have also developed a novel method to map water table depth (WTD) over large regions of peatland using satellite imagery. The study could significantly enhance our understanding of peatland's degradation state. The pilot study for this work covered an area of ca 20 km^2, using field water table depth measurements from 2018 as well as a series of optical and radar satellite imagery captured by the Sentinel-1 and Sentinel-2 satellites. The model was created by correlating the pixel values in the satellite imagery with the ground measurements of WTD.

To ensure the reliability of the model, the researchers conducted validation tests: part of the WTD observations that were not included in the model's construction and found that the model performed acceptably well. This validation is crucial as it confirms the model's potential for practical applications. The scientists then used the constructed model for the creation of detailed (20 m resolution) maps predicting WTD for the entire study area, and for the specific dates within the study period.

Unlike in the case of radar images, that are not affected by clouds, one of the major challenges in using optical satellite images in Scotland is frequent cloud cover, which can obscure the earth's surface. The researchers overcame this by creating a method to mask the clouds from

the images and restore their original values.

This study is an example of how innovative use of technology can provide us with deeper insights into our natural world. These new technologies, as well as being a scientific achievement in their own right, provide potential ways to monitor the degradation state of peatlands and their capacity for climate change mitigation. This project will eventually be able to provide spatially explicit information about current emissions, including areas that are still contributing carbon sequestration and areas where restoration could be considered, alongside mapping of emissions mitigation potential. This work will be linked with ongoing development of a model to forecast potential regional variations now and into the future (WP5).

For any further information, please contact the project PI Dr Rebekka Artz (rebekka.artz@hutton.ac.uk), or the WP2 leads Dr Matt Aitkenhead (matt.aitkenhead@hutton.ac.uk) for condition mapping, and Dr Alessandro Gimona (alessandro.gimona@hutton.ac.uk) for WTD modelling.

The Spark - SEFARI Gateway's Newsletter - November 2023

Healthy Soil for a Greener Recovery, CentrePeat, and Achieving Multi-Purpose Nature Based Solutions (AiM NBS) are projects which form part of he wider strategic research programme funded through the Rural & Environment Science & Analytical Services Division of the Scottish Government.

The Scottish environment Food and Agriculture Research Institutions (SEFARI) Gateway launched in November The Spark, the Centre of Expertise for Knowledge Exchange and Impact (CKEI) newsletter. The newsletter will provide a monthly update on the latest research developments from the Scottish Government's Environment, Natural Resources and Agriculture (ENRA) strategic research programme. The ENRA Research Portfolio provides evidence for policy and practice across environment, climate change, biodiversity, land use, agriculture, food, and rural community agendas.

To access "The Spark" please click here.

Welcome to the November 2023 edition of The Spark, SEFARI Gateway's (Centre of Expertise for Knowledge Exchange & Innovation) newsletter, a monthly update on the latest research developments from the Scottish Government's Environment, Natural Resources and Agriculture (ENRA) strategic research programme. The ENRA Research Portfolio provides evidence for policy and practice across environment, climate change, biodiversity, land use, agriculture, food, and rural community agendas.

ENRA Scientists working with SG on Rural Payments Scheme and Agricultural Reform Programme

Comments and upcoming issues: *The Soil Sentinel was produced as part of the **Healthy Soils (JHI-D3-1)** project with input from **CentrePeat (JHI-D3-2)** and the **Achieving Multi-Purpose Nature Based Solutions (AiM NBS) (JHI-D2-2)** project. We acknowledge funding through the Rural & Environment Science & Analytical Services Division of the Scottish Government. This is the 5th edition of The Soil Sentinel and we would welcome suggestions for articles, or requests for more information on any soil and plant interactions topics. If you would like to propose a contribution to the bulletin please don't hesitate to get in touch through **healthysoils@sefari.scot**.*