SEFARI

Leading ideas on soil

SRUC

Royal Botanic Garden Edinburgh

BioSS

Moredun

The Rowett Institute

The James Hutton Institute

Scottish Government
Riaghaltas na h-Alba
gov.scot

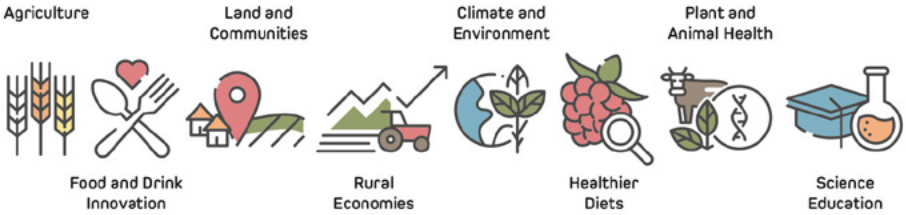
Leading ideas on soils

The Scottish Environment, Food and Agriculture Research Institutes (SEFARI) is a collective of six research institutes, each with their own global capability, expertise and reputation. The six institutes are: Biomathematics and Statistics Scotland, the James Hutton Institute, the Moredun Research Institute, the Rowett Institute, Royal Botanic Garden Edinburgh and Scotland's Rural College.

Through collaborative multi- and inter-disciplinary research, SEFARI are responsible, with Higher Education Institute partners, for delivering the Scottish Government (Rural and Environment Science and Analytical Services, RESAS) funded Strategic Research Portfolio on environment, agriculture, land, food, and rural communities (2016-2021). The Portfolio includes the Strategic Research Programme (SRP), Centres of Expertise, Innovation Partnerships and Underpinning Capacity funding of national resources within SEFARI.

The SEFARI Gateway is the knowledge exchange and impact hub for SEFARI. The Gateway works to enhance stakeholder access to the individual and interdisciplinary expertise of the Portfolio; to improve the flow of research-knowledge to and from the Portfolio to Scotland's policy, industry-sector representatives and public audiences and to increase the impacts from those activities. Gateway also seeks to ensure that Portfolio research is actively informed by stakeholders and knowledge networks across Scotland, UK and internationally.

SEFARI focuses its work under eight Leading Ideas



The important topic of soil spans across most of the Leading Ideas; included here are examples from Climate & Environment, Agriculture, Land & Communities, Healthier Diets and Plant & Animal Health. This leaflet highlights Scottish Government funded SEFARI strategic research to protect and make the best use of Scotland's many and varied soils which deliver so many of the benefits to life in Scotland.

Charles Bestwick
Director
SEFARI-Gateway

Lorna Dawson
SEFARI Advisor &
Sector Lead-Environment
SEFARI-Gateway

Contact us

www.sefari.scot

@SEFARIscot
#LeadingIdeas

info@sefari.scot

Soil dwelling insects in Working for Waders

Main contact: davy.mccracken@sruc.ac.uk

Across Scotland there has been a steep decline in the number of wading birds, including lapwings, oystercatchers and curlews, over the past 25 years. Farmers and land managers have an important role to play in reversing these declines, e.g. by applying lime to improve soil pH which can increase the abundance of invertebrates the birds prey upon. The Working for Waders programme was established in 2017 to raise awareness of wader declines, show how declines can be reversed and help support collaborative projects involving multiple farms, estates and landholdings. The programme is co-chaired by a SEFARI scientist and a colleague from Scottish Natural Heritage, and with SEFARI providing additional input in a range of ways.

- Working with the British Trust for Ornithology, wader distribution maps have been produced showing changes in wader populations across Scotland and hence where resources need to be targeted
- Wader scrapes, (shallow pools of water designed to allow waders access to invertebrate prey in wet soil around the edges) have been established on a SEFARI farm under the Agriculture, Environment & Climate Change Scheme and used as a focus for events aimed at raising awareness of wader management needs among farmers and crofters
- A suite of videos and podcasts targeted at farmers and crofters have been produced together with the Farm Advisory Service. The work of the programme has been highlighted through radio interviews and articles in the farming press

Waders and their chicks need to be able to probe in wet areas to find soil-dwelling insects and earthworms to eat. SEFARI work has shown that small changes on any individual farm or croft – such as not draining the wetter areas of one or two fields or even just smoothing out the sides of steep ditches - can actually make a big difference for waders on the ground.

Soil to grow really wild vegetables in

Main contact: w.russell@abdn.ac.uk

Home growers want tasty, nutritious and resilient vegetable varieties that can be grown with reduced fertiliser and pesticide inputs. Crop breeding has been driven by a focus on yield that does not necessarily meet their needs. A simple guide to sowing your own seeds is available.To develop more nutritious crops, which can be grown more sustainably, breeders across both home and commercial markets will need novel genetic resources that can act as sources of the desired traits.

Growth trials comparing domesticated vegetable varieties with their Scottish native wild ancestors have been used to explore variation in taste, nutritional quality and soil nutrient uptake with the aim of identifying useful genetic resources.

- Wild relatives of cabbage, carrot, beet and radish leaves contain significantly greater concentrations of plant-chemical compounds that have been linked to the prevention of non-communicable diseases caused by poor diet and lifestyle compared to heritage and modern varieties
- Soil chemistry and biology influenced nutrient content and needs to be considered when planting in new beds and planters
- In taste tests with the general public, wild relatives of cabbage were preferred by 51%, while 28% selected the heritage variety and 21% selected the modern high-yielding variety of cabbage

Knowledge of the beneficial traits present in Scottish native Crop Wild Relatives (CWR) will support the urgent need to conserve CWR both in the wild and in germplasm collections. This will help to support new crop varieties, created with human health, and due to reduced fertiliser and pesticide use, potentially greater environmental sustainability in mind. This will have important applications extending to commercial food production.

Soils and climate change

Main contact: bob.rees@sruc.ac.uk

In Scotland agriculture and land use contribute to around a quarter of the country's annual greenhouse gas emissions. Soils play a vital role in this as they emit carbon dioxide and the more powerful greenhouse gases nitrous oxide and methane. These emissions can however be offset by uptake of carbon dioxide which is sequestered in soils in the form of organic carbon compounds. Research in this area has therefore focused on minimising the emissions of greenhouse gases whilst increasing carbon dioxide removal from the atmosphere.

- Work in SEFARI has helped to significantly improve estimates of greenhouse gas emissions and ways in which these can be reduced by more efficient use of fertilisers and manures
- Working with farmers in a programme called Farming for a Better Climate we are helping to identify mitigation options, such as soil testing and optimising fertiliser and manure applications
- A large scale consultancy exercise (Agrecalc) is supporting farmers to 'carbon footprint' their operations to identify cost effective measures that can be implemented to reduce greenhouse gas emissions

With a focus on Scotland's soils, this SEFARI work in collaboration with Centre for Ecology & Hydrology and the Universities of Edinburgh and Aberdeen is helping to identify cost effective routes to reducing greenhouse gas emissions from agriculture and land use, as Scotland moves towards its target of net zero emissions by 2045.

Legume intercrops help improve soil quality

Main contact: john.baddeley@sruc.ac.uk

Recent policy changes have increased incentives to improve the environmental performance of farming, and one option being investigated in SEFARI is the greater cultivation of nitrogen fixing legumes, grown as either single species or in mixtures as an intercrop. One of the key benefits of including legumes in crop rotations is that they can improve soil quality for the following cash crops. Key indicators of soil quality have been monitored in field experiments with the aim of optimising these benefits for Scottish farmers. Key findings are:

- Single species of legumes tended to have a positive impact on key indicators of soil quality, such as potentially mineralizable soil nitrogen, soil structure and earthworm counts, although this effect depends on the plant species grown
- Intercrops of legume species consistently showed greater benefits to soil quality than single species

This work is allowing the development of specific, evidence-based agronomic and economic messages applicable to growers and advisors across Scotland on the benefits of legume-based intercrops to soil quality

Crop diversity, targeted inputs and residue management can improve overall system efficiency

Main contact: christine.watson@sruc.ac.uk

Long term sustainability of agricultural systems can be aided by a number of agroecological approaches that can help optimise productivity, economics, and ecological services of the overall system. Rotational diversity and the use of crop mixtures which utilise the assistance of biological nitrogen fixation from either forage or grain legume crops, allied to appropriate inputs, e.g. targeted lime applications and recycling of residues, can help maintain productive soils over many years. When focussing on low-input systems, the integration of livestock can provide a number of benefits over solely crop based enterprises in terms of nutrient recycling, maintaining soil organic matter and spreading economic risk.

- Stocked organic systems (either grazed or with manure return) have a tendency to be more productive and help to maintain soil organic matter which yields a number of benefits compared to stockless systems (that have no livestock inclusion)
- The choice of rotational sequence, targeted inputs and residue return, in association with integration of legumes can help maintain system efficiency, but it can take several rotational cycles for strengths or weaknesses of the chosen system to become apparent

Lessons have been learned about the influence that rotational sequence and approaches to residue management can have on soil properties (physical, chemical and biological) and productivity over the long-term. Given the long-term nature of the data from these experiments, in conjunction with local historical weather data, they are proving invaluable when testing models that investigate nitrogen and carbon cycling and climate change.

Interactions between soil & animal pathogens

Main contact: craig.watkins@moredun.ac.uk

Soil represents a critical meeting place for hosts and many of their pathogens, with a number of important animal pathogens living in, on, or percolating through the soil. This has obvious implications for livestock, wildlife, environment and human health.

- Cryptosporidium is an important pathogen in cattle where it can cause severe disease. It is also zoonotic and can be a serious risk to human health. Tracking infectious oocysts (eggs) from host animal to water sources has shown that soil and vegetation have an important role to play in the transmission of this parasite
- Microbial communities in water and soil may affect the prevalence of Johne's disease (paratuberculosis) in sheep. Research is being carried out analysing environmental samples from a farm with a high incidence of the disease in their sheep, offering opportunities for control
- The soil conditions required to support the mud snail intermediate host of the liver fluke parasite and the fluke risk to livestock associated with agri-environment schemes with respect to saltmarsh grazing, wetland creation and liming of pasture are being studied
- Soil screening is providing an improved understanding of the dissemination of Antimicrobial Resistance Genes (ARG) following application of commercial fertiliser and sewage sludge and the implications for grazing livestock and environmental contamination

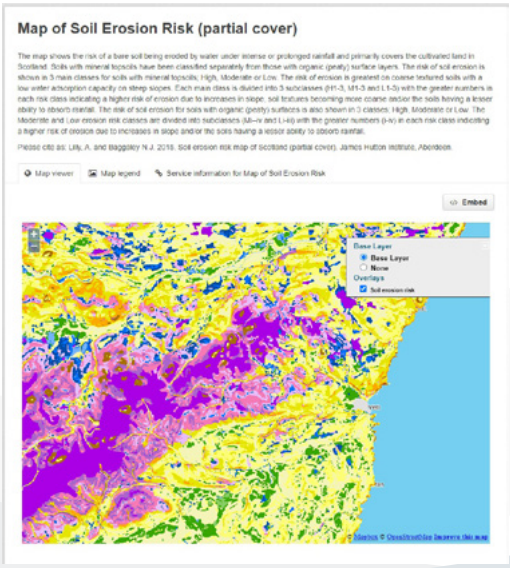
This research is leading to a better understanding of disease risk to animals and has provided solutions which reduce pathogen burdens on the farm, in the environment and in water courses, all leading to improved animal health and welfare, food safety, water quality and public health.

Opening a window on our natural assets register: data portal

Main contact: david.donnelly@hutton.ac.uk

Research conducted in the SRP has produced spatial data on Scotland's natural assets as either the key output, or as one of the supplementary results. Spatial data ranges from the distribution of soil organic carbon to references to landscape in cultural media. The science community has recently been improving its effectiveness in sharing its outputs. Our aim in creating the Natural Asset Register: Data Portal (NAR:DP) is to make spatial data results from SRP funded research as easily available as possible.

- The NAR:DP is a website where a collection of research outputs with a spatial component, brief descriptions, links to research papers, data on an interactive map and a download facility of the data can be obtained with a single click of a button. All this can be done without having to register on the site or complete any forms
- The resources in the NAR:DP are tagged by themes such as "soil" and "species richness". The resources tagged as "soil" include published research on peat and soil carbon and a suite of soil risk maps covering Scotland's more intensively managed farmland
- In addition to providing spatial data we also share the address of the web mapping services the site uses to display the mapped data. This makes it straightforward for any person or organisation with a suitable website or software on their PC to use the mapped data



The development of the NAR:DP means that an important set of the results of publicly funded research in Scotland are now more easily accessed and re-used than ever before.

Soil erosion in Scotland

Main contact: allan.lilly@hutton.ac.uk

The sustainable management of our soils is threatened by a combination of increased agricultural intensification and a changing climate. While increased mechanisation has brought many benefits to farmers and consumers through the production of high quality, relatively cheap food, common practices such as the creation of 'tramlines' can provide pathways leading to increased erosion. Extreme rainfall events are predicted to become more frequent and can cause widespread erosion on unprotected or damaged soils.

- Soil erosion can cause increased flood risk, loss of soil nutrients and soil carbon, reduction in crop growth, a loss of soil biodiversity and the pollution of rivers and streams by nutrient-rich sediment
- A simple, rule-based assessment of the risk of soil erosion by rainfall based on slope and soil characteristics has been developed and used to map the risk of erosion
- Field studies have shown that the use of 'very flexible', low ground pressure tyres can reduce sediment and nutrient losses from tramlines by up to 75%
- The use of cover crops and novel tillage methods have been shown to help bind the soil and maintain a soil structure that is more resilient to erosion and help increase soil biodiversity

While soil erosion in Scotland is not on the same scale as in some parts of the world, measures are being put in place to mitigate its effects including the use of cover crops, novel tillage methods and risk mapping to aid the sustainable management of Scotland's soils for future generations.

Read more>>

Nematodes as indicators species

Main contact: roy.neilson@hutton.ac.uk

A healthy and functioning soil is underpinned by the interactions between the physical structure and chemical environment of soil, soil organisms and plants. In the context of cropping systems, soil management is a driver of soil function and resilience. However, as soil is a complex and dynamic system, measuring change can be problematic. Traditional measures of status have been through soil chemistry (e.g. pH, nitrogen status) or physical (e.g. bulk density, structure) without consideration of the biological component of soils. Nematode worms are excellent candidates for use as a biological indicator of soil status as they are:

- Ubiquitous in all soils
- Easily extracted from most soils
- Well characterised into functional groups of bacterivores, fungivores, herbivores, omnivores and predators
- Globally accepted as an indicator of soil function[1]

SEFARI researchers are collaborating with commercial partners to develop an indicator of soil function by integrating national data on soil chemistry, physics and nematode communities. This research forms part of work currently being carried out for the Centre of Expertise in Climate Change to assess Scotland's capacity to measure the vulnerability of Scottish soils to a changing climate.

[1] https://doi.org/10.1038/s41586-019-1418-6

Trophic interactions - predatory nematode consuming its nematode prey.

Contact us

www.sefari.scot

@SEFARIscot
#LeadingIdeas

info@sefari.scot

SEFARI