BRITISH SOCIETY OF SOIL SCIENCE

1947—2017

70 years

Commemorating 70 years of the
British Society of Soil Science

**“THE NATION
THAT DESTROYS ITS SOIL
DESTROYS ITSELF”**

Franklin D. Roosevelt 1937

CONTENTS

PREFACE

HUMANS HAVE ALWAYS HAD A CLOSE RELATIONSHIP WITH SOILS, RECOGNISING THEM AS A SOURCE FOR FOOD, FIBRE AND FUEL.

In the 16th century land (soil) was considered the most important factor in the economy, and it became a belief that we could address problems of population distribution through fertilisation of deficient soils. Governments became increasingly interested in valuation of land for taxation purposes which required the evaluation and mapping of soils.

Whereas we are still actively debating the value of soils and the services it delivers four centuries onwards, the importance of soil has moved way beyond agriculture. Modern soil science has advanced from considering soil as an inert storage bin for water and nutrients, and the group of scientists that study soil today is probably as diverse as the soil itself. Whereas soils continue to form the basis of most food consumed worldwide, they also store and filter water, capture carbon which can help to combat climate change, are home to critical biodiversity and support much of our infrastructure. In fact, it is difficult to rank the importance of different services that soils deliver.

It is the diversity of Soil Science and the impact it has in various aspects of environment and society that created the inspiration for this book. The British Society of Soil Science has for the last 70 years promoted all aspects of Soil Science by advocating the importance of this discipline, the diversity it stands for and the important task we all have to secure soil as one of the cornerstones of the existence of mankind.

This book gives examples of contributions modern soil scientists make to society. Examples range from development of new technologies, training of young researchers and professionals, regulating ecosystem services, to influencing policy. The examples were presented at the Celebration of the 70th Anniversary of the British Society of Soil Science during a reception attended by their Patron, His Royal Highness The Duke of Gloucester KG GCVO.

The Society is proud to have served such a diverse and committed community for the last 70 years, and is looking forward to continuing to support the researchers and professionals working with the most important resource upon which all life on Earth depends.

Wilfred Otten, *President*
British Society of Soil Science
21st March 2017

HISTORY OF THE BRITISH SOCIETY OF SOIL SCIENCE

IT SEEMS THAT THE IDEA FOR THE BRITISH SOCIETY OF SOIL SCIENCE WAS ORIGINALLY DISCUSSED at a meeting of the British Empire Section of the International Society at the Bonnington Hotel, Southampton Row, London on 28th March 1946 and then formally accepted at a further meeting on 13th December 1946.

The provisional committee of the Society met at Rothamsted on 7th January 1947 where a set of rules and recommendations were made for submission to the next meeting of the Society.

The first Ordinary Meeting of the Society was held at the London School of Economics, Houghton Street, Aldwych, London, with 50 people attending, on Tuesday 15th April 1947. A presentation was given by Dr R.K. Schofield on *"A New Approach to Problems of Soil"*. The first President of the Society was Mr C. G. T. Morrison.

According to the records in the BSSS office, the first meeting of Council took place on 4th June 1947 at the Institute of Archaeology, Regent's Park, London.

Membership subscription was set at one guinea (1 pound and 1 shilling) and 126 members were registered in the year of formation.

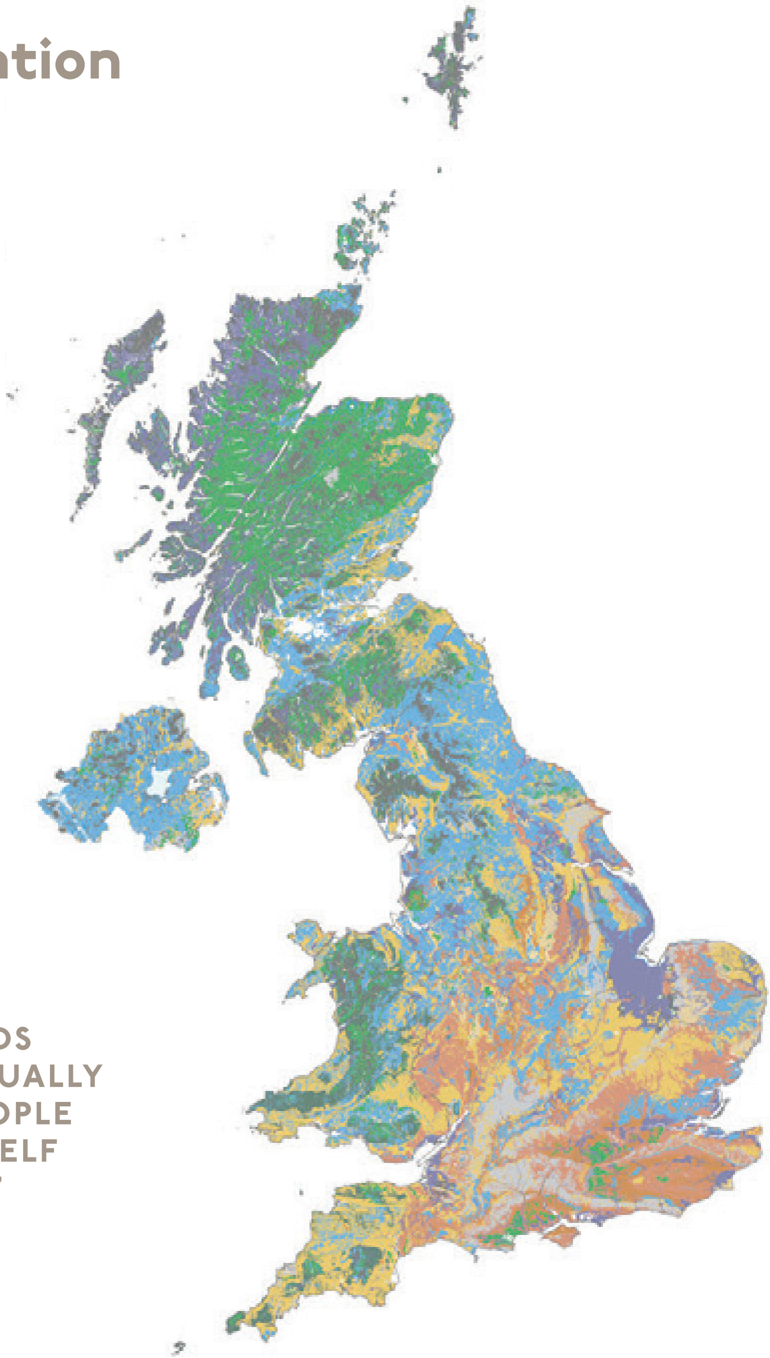
1950 saw the Society, in conjunction with Oxford University Press, publish the first *"Journal of Soil Science"*. The name of the journal was changed to *"European Journal of Soil Science"* in 1994. The Society produced a second Journal *"Soil Use and Management"* from 1985. Both Journals are now published by Wiley-Blackwell.

In 2008, the Professional Practice arm of the society set out to define the soil science qualifications, knowledge and skills required of professionals working in relevant land-based fields. These range from crop and livestock production to nature conservation and landscape design, from catchment management to the application of wastes to land. The outcome was publication of a set of *Working with Soil* professional competency documents in 2011.

In 2010 the Society merged with the Institute of Professional Soil Scientists and was incorporated as a registered charity.

At the 2014 World Congress of Soil Science the Society successfully bid for the right to host the 2022 World Congress on behalf of the International Union of Soil Sciences which will take place in August 2022. This is also the 75th anniversary of the Society.

Digital soil information



"WHILE THE FARMER HOLDS THE TITLE TO THE LAND, ACTUALLY IT BELONGS TO ALL THE PEOPLE BECAUSE CIVILIZATION ITSELF RESTS UPON THE SOIL."

Thomas Jefferson

The UK Soil Observatory (UKSO), World Soil Survey and Catalogue (WOSSAC), Land Information System (LandIS) and Scottish Soil Portal.

KNOWLEDGE OF SOIL TYPES AND PROPERTIES CAN UNDERPIN MANAGEMENT PRACTICES to develop sustainable agricultural production while maintaining the UK's carbon balance and a wide range of other functions, e.g. flood prevention, support for infrastructure, waste recycling & biomedical resources. Digital web based platforms are highlighting the UK's extensive soil data holdings for the public and business alike.

UKSO: **www.ukso.org** In the past, soils data, knowledge and expertise was scattered across a wide range of institutions. In 2014 these institutions joined forces in an effort supported by the Natural Environment Research Council (NERC) launching UKSO; an information portal that would serve to host or link to all these different soil data sources. It contains a total of 115 soil data layers which cover soil type (classification) and a wide range of properties and characteristics. Since its launch the site is used regularly with more than 2,000 users per week.

WOSSAC: **www.wossac.com** The mission of WOSSAC at Cranfield University, UK, is to provide a secure home for soil survey reports, maps, imagery and photographs produced by British companies and surveyors overseas over the last 80 years from 348 territories worldwide, with a view to ensuring their enduring availability and protection.

LandIS: **www.landis.org.uk** The "Land Information System", is a substantial environmental information system operated by Cranfield University, designed to contain soil and soil-related information for England and Wales including spatial mapping of soils at a variety of scales, as well as corresponding soil property and agro-climatological data.

Scotland's soils: **soils.environment.gov.scot** This website provides free access to data and information on Scotland's soils, including easy downloads of soil and land capability maps at a range of scales along with the associated soil property data. The site provides useful sources of data and information for researchers, land managers, planners, developers and teachers.

2015
International
Year of Soils

Princess Maha Chakri Sirindhorn celebrating World Soil Day with members of the IUSS and Thai Soils and Fertiliser Society

The International Union of Soil Sciences
The International Dimension
Stephen Nortcliff

THE INTERNATIONAL UNION OF SOIL SCIENCES (IUSS) HAS ITS ROOTS IN THE INTERNATIONAL SOCIETY OF SOIL SCIENCE (ISSS) WHICH WAS FOUNDED IN ROME IN 1924 TO REPRESENT INDIVIDUAL SOIL SCIENTISTS.

In 1998 following acceptance as a member of ICSU (International Council for Science) ISSS changed to IUSS with a membership of National Soil Science Societies. In 2017 IUSS represents over 40,000 Soil Scientists from over 60 countries. IUSS exists to promote all aspects of Soil Science amongst fellow scientists and the public and to support Soil Scientists.

In recent times, key activities have been the promotion of World Soil Day and the International Year of Soils. 5th December was chosen for World Soil day because it was the birthday of the late King of Thailand, Bhumipol Adulyadej, who strongly promoted sustainable soil management in South East Asia. In 2012 IUSS presented their Humanitarian Soil Scientist award to King Bhumipol in recognition of these activities.

Following this presentation the King asked his Government to support international recognition of World Soil Day. In December 2013 the United Nations General Assembly declared December 5 World Soil Day and 2015 the International Year of Soils. The International Year of Soils and World Soil Day were celebrated across the globe, but in particular in Thailand.

In celebration of the International Year of Soils, IUSS produced the booklet 'Soil Matters' which stressed the importance of soils across all aspects of our modern life. These included the role of soils in the environment, soils and land use, the increasingly important area of soil carbon and biodiversity, threats to the soil through our misuse and mismanagement, the task of placing a value on soil so that evaluations of alternative uses may be made, and the role of soils in religion, history, culture and education. This booklet illustrated the growing recognition of the importance of soils beyond the traditional concerns related to biomass production.


SUSPECT

Soil Forensic Science-delivering intelligence and evidence to the criminal justice system

SOIL CAN PROVIDE VITAL CLUES ABOUT HOW DEATH MIGHT HAVE OCCURRED OR HOW CRIMES WERE COMMITTED, OR CAN HELP IN CRIME RECONSTRUCTION, ULTIMATELY HELPING TO COMPLETE THE INVESTIGATIVE JIGSAW OF CRIME INVESTIGATION.

Soils contain many physical, chemical and biological characteristics, including bioindicators such as diatoms, pollen grains and trace plant debris, all of potential use in the forensic investigative process. Soil is a complex and heterogeneous material with regular contact with people, vehicles, tools and objects. That complexity and contact (with transfer) can provide specificity to location. Field survey, Geographical Information Systems (GIS) and understanding soil, hydrology, vegetation and geology are central to developing search strategies in the field. Soil science helps both in the intelligence stage of an investigation and also can provide physical trace evidence ultimately as presented in court.

Soil mineralogy, elemental composition, organic characterisation, botanic fragments, diatom, fungal and nematode identification, plant and seed DNA analysis, and bacterial DNA profile characterisation are some of the characteristics that we at the James Hutton Institute use in casework. GIS has been developed to allow the mapping of evidence and the exclusion of areas of land in search operations, enabling police to fine-tune areas on the ground in the search for missing persons or objects. Vehicles, footwear, clothing, spades and tools, as well as trace amounts of material, e.g. found under a fingernail can now also be examined, recovered and analysed, potentially turning round a sample analysis and interpretation in less than 24 hours helping in the critical search operations when a person goes missing.

Soil Forensic Science Soil has been used as part of many high profile searches and as evidence in many court cases: for example, in the Worlds End murders, Edinburgh, HMV v Sinclair — the first ever double jeopardy case and in the Becky Godden murder trial, Bristol, R v Halliwell.

House of Commons

Environmental Audit Committee

Soil Health

First Report of Session 2016–17

House of Commons Inquiry on Soil Health

IN 2016, THE HOUSE OF COMMONS ENVIRONMENTAL AUDIT COMMITTEE (EAC) CARRIED OUT AN INQUIRY INTO HOW SOIL HEALTH CAN BE BETTER MEASURED AND MANAGED. Submissions from a wide cross-section of the community were received. Many highlighted that soil, water, biodiversity and air are all essential to human life and society—but of these four, soil was often the forgotten component or the 'Cinderella' of our natural resources. Some key statistics the Committee heard concerning current soil degradation included:

- 11% loss of soil organic carbon in arable soils over the last 30 years.
- 84% loss of peatlands in East Anglia.
- 325,000 sites in the UK affected by some degree of contamination, covering an area of 300,000 hectares.

These losses are hard to replace because UK soils are relatively young, having formed since the last ice age around 10,000 years ago, and grow slowly, taking around 100 years to grow 1cm of topsoil. Wider environmental, social and economic impacts include:

- An estimated economic cost of soil degradation of £0.9 — 1.4 billion per year.
- A link between self-reported health issues and brownfield sites even when controlling for socio-economic factors.

Furthermore, the Committee heard that current measures in England for ensuring protection of soil health is a 'damage limitation policy at best' with ineffective policing and there is no active UK soil monitoring programme.

The Committee's recommendations published in May 2016[1] were to:

- Identify funding for identification and remediation of contaminated land.
- Identify and police action to prevent loss and increase soil organic carbon to meet international commitments such as the '4 per mille' initiative (**www.4p1000.org**).
- Take tougher action to tackle land use practices which degrade peat.
- Restructure renewable energy subsidies to avoid high risk practices such as maize on erodible soils.
- Commission a national monitoring scheme to ensure soil health is regularly assessed.

References

[1] **www.publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/180/18002.htm**


GREAT
soils
Resilience,
productivity and life

AHDB Research Partnership: Management of Rotations, Soil Structure and Water

Most growers understand the importance of soil, but many are unclear as to how best to measure change and manage improvements. The GREAT soils project team is helping growers to make positive changes by working with them to assess soils using a range of methods, by looking at management approaches to improve soil health and by producing training resources for growers to complement subject-specific AHDB factsheets.

A Cranfield University report [CP107], funded by AHDB and published in 2013 outlined a series of priorities for research on soils used for horticultural cropping. Techniques for measurement and management of soil health and precision horticulture were identified as being of key importance and two of the three projects since commissioned (including GREAT soils) are outlined here.

GREAT soils ([CP107b] 2015–2018)

Aims: To inspire and support fruit and vegetable growers (primarily) to develop the ability and confidence to assess the health of their soils and take practical action to improve their soil management strategies.

Key outcomes so far:

- Current approaches to measure soil health have been reviewed and compared.
- More and more growers are engaging with the project and with each other to talk about soil health
- Growers and grower groups all over the UK are digging assessment pits in their fields, assessing their soils and measuring soil health.
- Vegetable, salad and fruit growers are trialling methods to improve the health of their soils using composts, crop management techniques and green manures.

Deliverables (ongoing): practical workshops, "Field Labs", seminars, conferences, webinars, guidance documents and case studies.

Precision Farming Technologies to drive sustainable intensification in horticulture ([CP107c] 2016–2018)

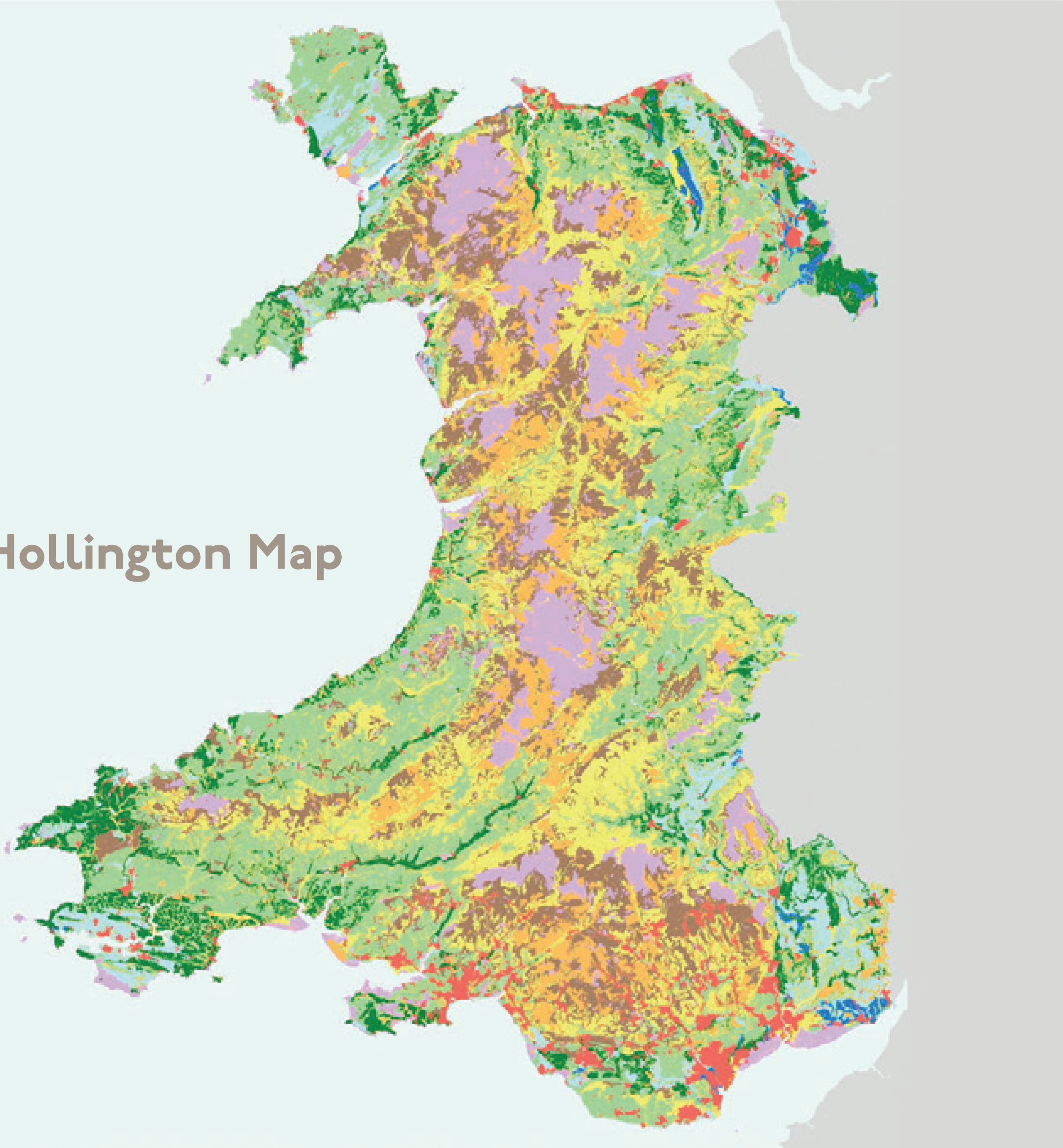
Aims: To evaluate the current and future potential of precision farming techniques to optimise soil and nutrient management for improved profitability and sustainable intensification of horticulture crop production systems.

Key outcomes so far:

- Soil structure survey: 75 fields covering a range of crops have been identified, pre-and post-planting soil assessments are complete.
- Precision farming review: information has been collated on the potential of precision farming techniques to improve soil and nutrient management and associated productivity and profitability in horticultural cropping systems.

Deliverables (ongoing): Grower guide to improve soil and nutrient management; demonstration trials and open days assessing potential of different precision techniques in horticultural cropping.

The Hollington Map



The Land Capability Model for Wales

WELSH GOVERNMENT COMMISSIONED CRANFIELD UNIVERSITY'S INSTITUTE OF SOILS AND AGRI-FOOD TO DEVELOP A LAND CAPABILITY MODEL FOR WALES.

The model allows land users, planners and policy makers to assess agricultural potential across Wales, to make informed decisions over the use of land.

It uses the Agricultural Land Classification system to assign a grade based on long term physical limitations on the land. Grade 1 is excellent and Grade 5 is very poor.

Wales' most productive land is only 7 to 10% of its surface area. Welsh Government policy identifies this land as a finite resource, which must be conserved.

Inappropriate use of our most productive soils affects the ability of future generations to adapt to shocks and take advantage of opportunities in a globally responsible way.

The primary purpose of the model is to support the planning system when considering the use of Wales' most productive land in development management decisions.

The model is already being used in a wider role. It supports pioneering Welsh legislation on the sustainable management of natural resources: the Well-being of Future Generations Act (2016) and Environment Act (2016). This model can predict soil resources under existing developed areas. It can be used to model soil loss rates; analyse growth trends; assess the significance of loss and what it means for Government policy.

Soil sealing is considered a significant threat to soils. Every year in Europe, soils covering an area larger than the city of Berlin are lost to urban sprawl and transport infrastructure. Every ten years in Europe, an area the size of Cyprus is paved. Sealing could be seen as a bigger threat to agricultural futures than erosion and compaction combined.

Our modelling system allows Wales to understand the resource dynamics to better inform Government policy.

The Soil Security Programme adopts an integrated approach which will unite scientists from a range of specialist areas, including the plant, soil, microbial, ecological and modelling communities.

The Soil Security Programme

THE SOIL SECURITY PROGRAMME IS A MULTI-MILLION POUND INVESTMENT LED BY THE NATURAL ENVIRONMENT RESEARCH COUNCIL PARTNERED BY THE BIOTECHNOLOGY AND BIOLOGICAL SCIENCES RESEARCH COUNCIL, DEFRA AND SCOTTISH GOVERNMENT.

The overall aim of the programme is to deliver improved forecasts of the response of the soil system to changes in climate and land management at the scale of decision making. To achieve this we need to understand the ability of soils to perform multiple functions in different contexts at different scales and their ability to resist, recover and adapt to perturbations, e.g. land use change, extreme climatic events. When this knowledge is available we can then define suitable metrics of sustainability to identify and prioritise appropriate management interventions.

The programme consists of fifteen projects which range across scales e.g. the influence of soil management on microbial populations, developing plant species to modify soil structure, and using remote sensing techniques to monitor changes in peatlands. The research is being undertaken at more than 20 research institutes across the UK. There are over 30 early career scientists on the programme including 4 Research Fellows who are pursuing projects they have designed themselves.

This cohort of young researchers regularly gather for workshops and are developing links with the STARS centre for doctoral training (**www.starsoil.org.uk**) to develop the next generation of soil scientists, another goal of the SSP.

Finally through a range of knowledge exchange activities we are developing close engagement with policy and practitioner communities who will be essential if we are to realise our ambition to deliver research outcomes that are policy ready and can provide sustainable soil management.

STARS
Soils Training And Research Studentships

STARS (SOILS TRAINING AND RESEARCH STUDENTSHIPS) IS A CENTRE FOR DOCTORAL TRAINING, COMPRISING EIGHT UNIVERSITIES AND RESEARCH INSTITUTES IN THE UK.

STARS research focusses on four integrated thematic topics: the soil-root interface, ecosystem services, resilience and responses of soil functions to global change, and modelling the soil ecosystem at different spatial and temporal scales.

The STARS programme provides a unique training experience for students, combining workshops at partner organisations, summer schools and international field visits and conferences.

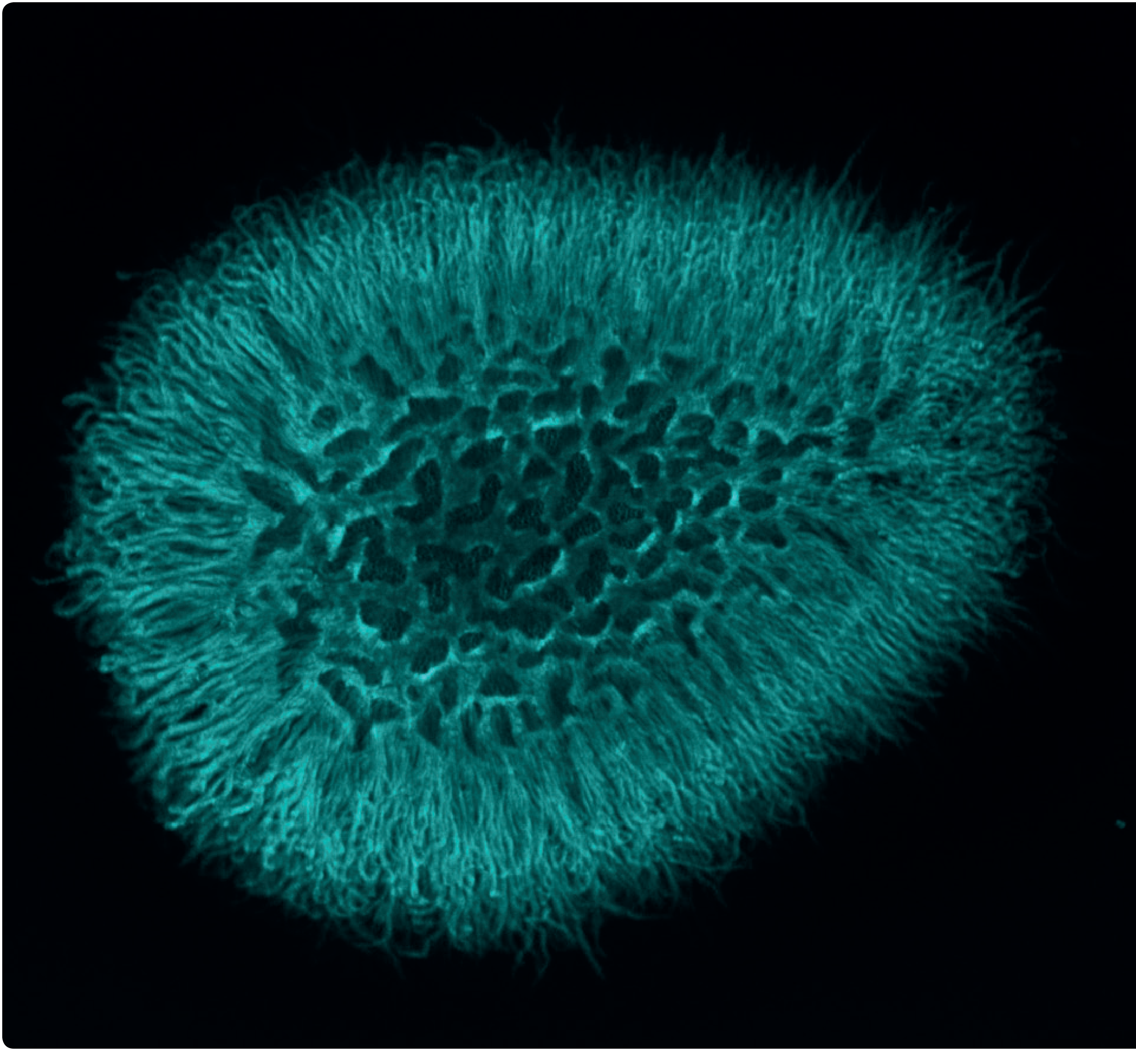
Amongst other global issues, STARS is addressing the multiple challenges in farming: with agriculture accounting for 10—12 % of global greenhouse gas (GHG) emissions and an estimated 12 m hectares of soil a year lost through degradation, the task to feed a global population of 9 billion, whilst minimising effects on climate change by 2050, is critical.

Second year STARS students recently visited Tenerife (top left image) to broaden the cohort's knowledge of soils and their formation processes, not normally seen in the UK, such as Vertisols, Andisols, Oxisols and Ultisols.

A group of first and second year STARS students secured places to visit the Federal University of Lavras (bottom image), in Brazil with a focus on description, classification, and chemistry of tropical soils together with the major land-use challenged in tropical region and how these impacts upon soils.

68% of agricultural land in the UK is managed by conventional tillage, which can lead to deterioration in structure, increasing the chances of soil erosion and enhancing carbon dioxide (CO_2) emissions. Consequently, alternative tillage systems have been developed under the wider term "conservation agriculture" (CA) since the 1940s. CAs popularity has increased over the last 10 years, increasing by 8.1 m hectares in Europe. CA encompasses all practices that conserve soil and water by minimising soil disturbance and leaving at least 30% of crop residue on the surface. This practice may present climate change mitigation opportunities due to the possible carbon storage capacity in soil and reduced CO_2 emissions.

One STARS project aims to establish how CA influences soil properties and GHG emissions. This project utilises sampling across the East Midlands to assess contradictory research regarding GHG emissions and long-term storage of carbon. Novel techniques, including X-ray Computed Tomography, Rock-Eval and denitrification incubation systems will be applied to elucidate soil responses to tillage practices.



Harnessing ecosystem services

SOIL EROSION DEGRADES THE PHYSICAL AND BIOGEOCHEMICAL FUNCTIONING OF ARABLE SOILS, THREATENING SUSTAINABLE FOOD PRODUCTION.

The severity of soil erosion is intensifying due to recent increases in the frequency of storm events. Weed seedbanks may act as a vital buffer against short term disturbance events, whilst providing other important ecosystem services within simplified agroecosystems.

Myxospermy is a common trait among many arid and semi-arid plant species and has ecological significance for germination, dispersal and dormancy. Upon hydration, the seed becomes enveloped in a hydrophilic mucilage sheath which ruptures the primary cell wall. The composition of seed mucilage can be very complex and challenging to ascertain, with only a few model species previously observed. This acidic hydrogel is comprised of two layers: the inner layer contains cellulose fibres embedded in a pectinaceous matrix and remains adherent to the seed; the outer, non-adherent, layer is soluble pectin and thus capable of influencing soil biogeochemistry. The adhesive nature of mucilage can physically alter soil, stabilising structure and enhancing water retention, and therefore has important implications for soil health and the sustainability of arable production systems. However, quantitative studies are rare and often limited to a single model species.

Here, we are characterising the composition, structure and relative mucilage production of six arable weed species with the aim to understand the underlying mechanisms occurring between seed-soil mucilage interactions. For the first time, we can show structural differences between species and how this may influence their ability to adhere to soil particles. We are currently developing a method which will allow us to quantify the capability of these myxospermous communities to alter their movement and soil transport during runoff erosion events. From this research, we will have a better understanding of the biophysical linkages between seedbank composition, soil properties and land management which will contribute to policy drivers of sustainability and food security.

◀ *Harnessing ecosystem services that lie within the soil is the key to retaining biodiversity and securing sustainable agriculture.*

WORKING WITH SOIL

setting standards in soil science

The Working with Soil programme
Setting and achieving standards in field soil science

IN MANY PROFESSIONS, ONE CANNOT WORK WITHOUT APPROPRIATE QUALIFICATIONS. Medicine, law, engineering, chartered surveying all operate according to the principle that practitioners must be adequately qualified and experienced. The Professional Practice arm of the Society believes that the same should be true of soil science. The *Working with Soil* initiative is the means to that end.

Competency definitions

The scheme has two tiers. All field soil scientists are expected to be able to expose, describe, classify and interpret a soil profile. They should also understand how soils vary within a landscape and the factors that cause that variation. These are the Foundation skills that form tier one.

At tier two, *Working with Soil* identifies the required qualifications, knowledge and skills specific to particular tasks and/or commercial sectors. There are competency definitions for the following.

- Agricultural Land Classification (England and Wales)
- Soil science in integrated soil and water management
- Soil science in soil handling and restoration
- Soil science in land evaluation and planning
- Soil science in the establishment, management and/or conservation of natural habitats and ecosystems
- Soil science for the application of organic materials to land
- Soil science in landscape design and construction
- Research and development leadership
- Soil science in crop and livestock management

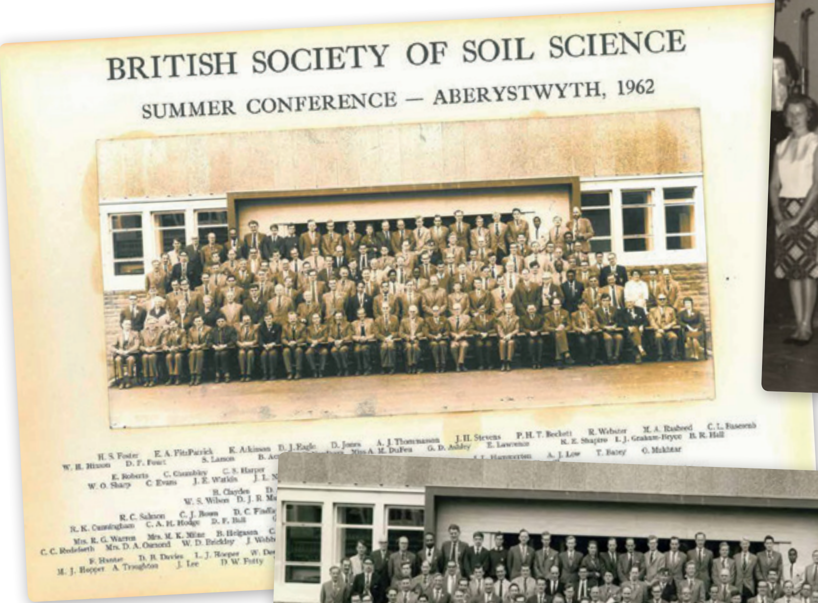
At its launch in 2011, the scheme was supported by over fifty organisations from across the public and private sectors. The documents are downloadable from the Society's website and organisations commissioning soil-related work are encouraged to use the documents to ensure that they select appropriately qualified professionals.

Training

To date, our training courses cover the Foundation Skills, Agricultural Land Classification, and Soil Handling and Restoration. Our next priority is soil-related aspects of crop and livestock management. Typically, our courses are attended by 10—20 delegates and are taught by two or three volunteer trainers who are members of the society. Everyone who has attended a course has rated it excellent or good in feedback.

As well as early career scientists, *Working with Soil* courses have proved attractive to students. Soil science is now not taught in any depth at any UK university or college. Young soil scientists find it difficult to gain practical experience of real soils in the field. *Working with Soil* provides that opportunity and is a very rewarding experience for all concerned.

The Society in pictures




journey through
the rabbit hole


Soil
Organic
Carbon

Soil Organic Carbon:
Powering The Soil — Plant — Food Health Continuum

SOC provides the energy for biological processes in soil. We hypothesise that sufficient supplies of energy-rich and nutritious food starts with the management of SOC to provide soil organisms with the energy and nutrients that they need to drive soil functions.

Can we manage soil organic carbon to close the yield gap? The yield gap is the difference between the maximum potential yield and that actually achieved by farmers. Our recent work suggests a direct link between increasing SOC and yield increase in cereal crops.

SOC and self-organisation of soil. Surprisingly predictable soil structure(s) emerge(s) as soil organisms consume resources and influence the arrangement of soil minerals around them. We have observed, extracellular polymeric substances (EPS) produced by soil microorganisms that hold soil particles together in agricultural soils.

SOC hotspots around roots. We are investigating whether the biological communities that live in the rhizosphere can be manipulated to improve crop growth and nutrient uptake and reduce losses to the environment.

Big roots for carbon sequestration. We are exploring whether SOC can be increased more rapidly under forage grasses with large and deep roots, and the relationship with the nutrient content of the leaves.

Zero tillage and earthworm activity. SOC improves soil structure and the supply of water and nutrients to plants. A new experiment at Woburn Farm is investigating the link between the activity of earthworms and crop yields in fields that have been zero tilled.

Resilience — the legacy of SOC for the future. We manage SOC not only to maximize today's yield, or to absorb today's emissions, but to buffer against tomorrow's stress.

Critical role for long term experiments in SOC studies. Long term experiments are vital to our understanding of SOC dynamics, and highlight the need for continued investment in all long term agricultural experiments across the world.

> "We're bringing together growers with multinational food companies, NGOs, the input industry and academics to mitigate greenhouse gas emissions and other environmental eimpacts."

> "The Cool Farm Tool is simple to use, yet scientifically robust, in the complex area of carbon accounting, and has already helped brands make dramatic reductions in emissions."

The Cool Farm Tool

CREATING HEALTHY SOIL HAS NEVER BEEN MORE IMPORTANT — FOR ENSURING A GROWING FOOD SUPPLY, and because improving soil carbon stocks through sequestration plays a big part in agricultural efforts to tackle climate change, reducing atmospheric concentrations of CO_2. And healthy carbon stocks are linked to good soil function, so help ensure stable food supply.

The Cool Farm Tool puts the science of soil and climate change in the hands of decision makers. The food and drink industry with a combined, estimated 10% of global GHG emissions in their supply chains, use the Cool Farm Tool to find ways to sequester soil carbon and reduce emissions.

The Cool Farm Tool is now the most widely used global calculator for calculating on-farm GHG emissions, with supporting metrics for biodiversity and water. The tool is simple to use, yet scientifically robust, in the complex area of carbon accounting, and has already helped brands make dramatic improvements. Pepsico, for example, has achieved a 50% reduction in GHG emissions from UK agriculture.

The Cool Farm Tool has sprung an industry platform and an academic hub. The Cool Farm Alliance is the largest global network of organisations tackling on-farm emissions. Over 15,000 Cool Farm Tool farm footprints have been generated in over 60 countries. Given the global nature of food supply chains, the Tool's scope and applicability — all major crops and livestock — are essential to deliver significant mitigation impacts.

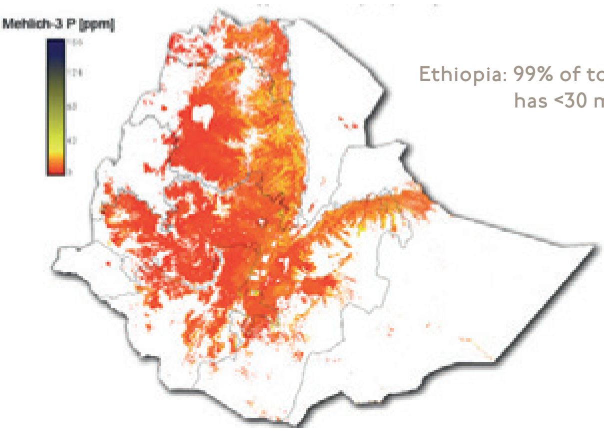
The Innovation Hub has drawn together experts from across the natural sciences to coordinate research efforts to help implement the Alliance's strategy.

"If there is any sector of the economy which we should try and make carbon positive, it should be agriculture. CFT is the kind of tool you need to understand how you might do that," says Jan Kees Vis, Global Director Sustainable Sourcing Development, Unilever.

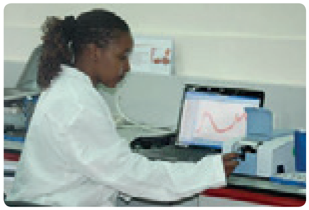
Information for Accelerating Agricultural Adaptations in Africa

AfSIS developed a suite of tools to quickly collect spatial information on soils, crops, land use and landscapes in Africa. This information is then available for all stakeholders in the further development of African agriculture.

Croplands: currently ~ 6.7 out of the 30 million km² African continent



Ethiopia: 99% of topsoil (0–20 cm) in cropland has <30 mg/kg phosphorus



Innovative dry spectroscopy analytical techniques established by AfSIS, make it possible for more economic and high throughput analysis of soil, plant and fertiliser materials.

Africa Soil Information Service (AfSIS)

THE AFRICA SOIL INFORMATION SERVICE (AFSIS) PROJECT IS FUNDED BY THE BILL AND MELINDA GATES FOUNDATION.

The objective is to increase smallholder farmer (SHF) productivity and to promote national and private sector policy changes towards more sustainable agricultural production. The project puts a particular emphasis on soil health and associated geospatial information through innovative information products and services.

In addition, the project expects to increase the returns on public investments in agriculture and sustainable agricultural production growth by informing research programs, governments, businesses, decision makers and development practitioners about opportunities and constraints for increasing agricultural production and sustaining other ecosystem services at geographical scales ranging from individual fields to the entire African continent.

AfSIS objectives reflect its four main work streams:

- Development of soil and landscape information infrastructure and systems including core databases, protocols, standards, software, IT and data science.
- Creation of agronomic decision support applications that add value and inform decision making at multiple levels, from national and regional policy formation to farm-level land management with project partners.
- Institutionalisation, capacity strengthening and learning support for deploying institutional soil and landscape information systems and services.
- Sustainable business development and communications innovation support.

The project assists national programs in at least four African countries to transition to modern agricultural research and data collection practices that are expected to result in faster agricultural development. For example, for Ethiopia more than 15,000 soils have been analysed and mapped, resulting in more appropriate fertiliser blends being applied. In Tanzania, more than 10,000 soil samples with crop information were collected and key crop distributions mapped.

Project outputs are also informing national and global policy and initiatives in agriculture that address key environmental threats in South Saharan Africa with e.g. soil and landscape monitoring systems that are compliant to international standards.

AfSIS will also continue to focus on distribution and capacity building for its information technology with governmental and non-governmental organisations in e.g., Ethiopia, Ghana, Nigeria and Tanzania.

Soils, food, farming and rivers:
How soils can contribute to the prevention of diffuse pollution and flooding

SOILS HAVE AN INHERENT ABILITY TO HELP US STORE WATER AND NUTRIENTS. This means that whilst soils can underpin our food supply by hosting crop and animal production, they can simultaneously play a pivotal role in controlling the downstream effects on river catchments, lakes and estuaries.

The structural, textural, chemical and biological attributes of soils combine to give excellent properties for holding water in pore spaces and retaining nutrients for plant growth. Soils that can develop a good structure have an increased hydraulic conductivity, which means they can help soak up rain water, rather like a sponge. Soils also retain and store nutrients such as nitrogen and phosphorus and can help the farmer optimise the storage and supply of nutrients to plants, by ion exchange on particle surfaces and incorporation into the soil's organic matter.

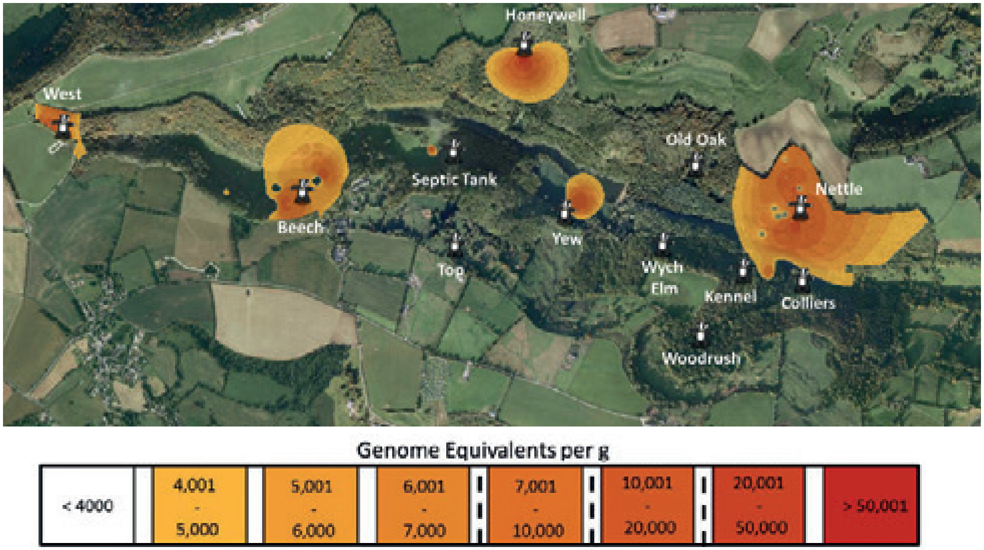
This research focuses at this interface between soils and waters, studying the way in which soils can be encouraged to hold fertiliser nutrients at an optimal level to supply plants for food production, but critically defining conditions that prevent the unwanted leakage of nitrogen and phosphorus out to waterways. In much the same way that nutrients help crops grow, if they inadvertently escape the soil they can also help the proliferation of undesirable aquatic plants in rivers lakes and estuaries.

When nitrogen and phosphorus reach certain levels in water bodies, the nutrients contribute to eutrophication and the development of toxic algae, which consume aquatic oxygen undermining biodiversity and ultimately rendering water useless for drinking water or recreational activities. Soil management can also help store and slow water flows, which can contribute to the flood control in downstream catchments

This research has been to help the UK government develop policies that help farmers and catchment managers optimise plant uptake of nutrients but minimise losses to water. Often this involves efforts to reduce runoff energy, which can have dual benefits for both diffuse pollution and flood control. Specific lines of research and impact include:

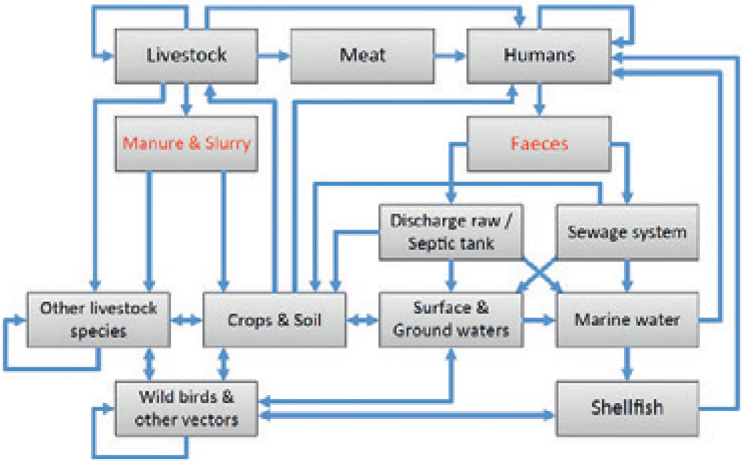
- Development and maintaining 'Demonstration Test Catchments' that can help provide a focal meeting point.
- A focus on plant types that have benefit traits, such as the potential to be efficient users of phosphorus or rooting qualities that 'soak up' runoff water.
- A consideration of what may happen to flooding and diffuse pollution under future climate change scenarios.

- Tracking the dissemination of pathogens into the environmental — molecular forensics to study faecal shedding of *Mycobacterium bovis.*



- Analysis of pathogen shedding from social groups of badgers in pastures, only infectious animals shed the bacterium which causes bovine TB.

Transmission pathways for spread of antibiotic resistant bacteria



Resistance genes can be tracked between man and animals and soil and water as the environment connects all these reservoirs

Soil as a reservoir for pathogens and antimicrobial resistance

SOIL CONTAINS THE MOST DIVERSE MICROBIAL POPULATION ON EARTH BUT CAN ALSO ACT AS A REPOSITORY FOR PATHOGENS WHICH MAY OR MAY NOT BE VIABLE.

Long term studies of pathogen shedding in wild life such as badgers have enabled us to map infection in social groups to understand better the transmission dynamics of bovine TB and the dissemination of the pathogen *Mycobacterium bovis*. Using molecular detection methods on DNA extracted directly from soil it is possible to track specific pathogens and try to resolve infection levels but also most importantly potential environmental reservoirs of disease. In the case of bTB we still need to determine how disease is transmitted and if the environment acts as a source of infection.

Pathogens are constantly shed by their hosts into the environment but this process can be accelerated by the recycling wastes such as sewage sludge and manure. These are important routes for the fertilization of soil with introduction of NPK but this can be accompanied by a high bacterial load and some of these bacteria may carry antimicrobial resistance genes. This has become a serious concern as we use antibiotics both in human and veterinary medicine thus selecting for resistance in human and animal pathogens causing infections and also in microbiomes exposed to antibiotics.

Current research has demonstrated that resistance genes can persist in the soil environment following application of farm slurry and resistance is more prevalent in land receiving sewage cake. Work continues to determine if these resistance genes pose a hazard to human and animal health and disturb the natural equilibrium of microbial antagonism which is the important process of microbial competition in the rhizosphere of plant roots. The natural microbiome of plants and animals is important for development of immunity and also harbours natural antibiotic producers which may be affected by the dissemination resistance.

Soil erosion: a significant threat to the sustainability of global agriculture

SOIL EROSION PRESENTS A THREAT TO AGRICULTURAL PRODUCTIVITY, PARTICULARLY BUT NOT EXCLUSIVELY, IN REGIONS WHERE AGRONOMIC INPUTS ARE LOW, VEGETATION COVER IS POOR, SOILS ARE NOT RESILIENT AND WHERE INTENSE RAINFALL SOMETIMES OCCURS.

Highest erosion rates are often in semi-arid and tropical regions. Soil erosion is strongly affected by human impact: due to agricultural activity, rates of soil erosion exceed the rates at which soil is formed, which are typically in the range of 0.001 — 0.1mm yr-1 (although we have very little reliable data on this), we risk literally running out of soil, but the timescale over which this may occur is unclear. For example, farmers in parts of the South Downs are already farming in rock rubble. Maintaining and enhancing the productive capacity of our soils must therefore be a priority.

The main agents of soil erosion are wind, water and tillage. Water erosion is most often initiated by rainfall impact degrading the surface structure of exposed soil, reducing permeability and causing the generation of surface runoff leading to sheet, rill and gully erosion. Tillage erosion refers to the redistribution of soil due to the mechanical action of tillage implements, whereas wind erosion is characteristic for lighter organic or sandy soils.

Globally it is estimated that water erosion mobilizes 28 billion tonnes of soil every year, which together with 5 billion tonnes and 2 billion tonnes of sediment mobilized by tillage and wind erosion each year, respectively, gives a total flux of about 35 (±10) billion tonnes per year: approximately 5 tonnes of soil for every person on our planet.

The good news is that researchers and farmers have not been idle and there is a toolbox of soil conserving measures available. For many situations management practices to control or decrease erosion are well documented and demonstrated to be effective — yet they are frequently not applied. The reasons for non-adoption are numerous and often complex and inter-related, but urgently need to be tackled.

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See you at the World Congress of Soil Science in Glasgow, 2022

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