Written evidence submitted by the James Hutton Institute

Executive Summary

How could soil health best be measured and monitored? How could the Government develop a strategy for tracking soil health?

- Although techniques are constantly evolving and further work is needed to develop cost-effective, easy to use and rapid indicator methods, current knowledge is sufficient and appropriate to establish robust soil monitoring in the UK;
- Monitoring should utilise a range of techniques and tools – field, laboratory, remote sensing and citizen science – in partnership with other ongoing initiatives;
- The purpose of the monitoring should be clear, and links between the monitoring activity and the soil function (and policy) should be explicit.

What are the benefits that healthy soils can provide to society?

- Soils are fundamental to national food security;
- The UK National Ecosystem Assessment (2011) highlights the vital role that soils play in the delivery of ecosystem services;
- There is a lack of economic data relating to soils and many of their benefits;
- Sustainable soil management is vital in the delivery of many societal benefits;
- The costs of impacts on soil health are often borne off-site of the location of the soil in question.

What are the consequences of failing to protect soil health for the environment, public health, food security, and other areas?

- There are notable historical precedents for failing to protect soil health, such as the American Dust Bowl and China's river eutrophication, each the result of inappropriate soil management;
- The UK will experience reductions in food production with consequences for food security, difficulty in achieving water quality standards, increased flood risk, increased GHG emissions, and loss of biodiversity.

What measures are currently in place to ensure that good soil health is promoted? And what further measures should the Government and other organisations consider in order to secure soil health?

- Generally, measures rely on voluntary principles and opt-in from practitioners; GAEC (Good Agricultural and Environmental Condition) standards are limited in relation to securing soil quality;
- The DEFRA "Terrestrial Umbrella" approach relies on coordination by all relevant organisations and, given the multi-benefit and cross-cutting role of soils, a similar approach should be extended to soil quality and its off-site impacts.

What role (if any) should soil health play in the Government's upcoming 25 year plan for the natural environment?

- Given the multiple benefits it supports, soil must feature strongly in the Government's upcoming 25 year plan for the natural environment;
- There is a need for a 'championing body' to coordinate this inclusion; currently soil intersects a number of policy sectors with resultant issues of adequate integration;
- Many public policies and international obligations (e.g. Aichi, IPCC, Water Framework Directive) cannot be met if soils are not explicitly included in land, ecosystems and freshwater management;
- The training and education of soil scientists should form part of the strategic planning by government for the natural environment.

Introduction

1. The James Hutton Institute's response to the Soil Health Inquiry has been collated from Institute experts including soil scientists and researchers across several soil-related disciplines. The Institute has a long track record in soils research, including investigation of soil properties and processes, agricultural and environmental impacts of soil management, and policy development and implementation. We hold the National Soil Archive of Scotland and the national soils mapping for Scotland, resources which have been extensively used in the study of soils and change over time.

Response to Consultation Questions

How could soil health best be measured and monitored? How could the Government develop a strategy for tracking soil health?

2.1. All soils are multifunctional and provide multiple benefits, making their monitoring especially challenging (UK National Ecosystem Assessment, 2011 www.uknea.unep-wcmc.org). Any soil health monitoring strategy must accommodate the inherent variability of soils, which reflects their capacity to deliver multiple benefits. The definition of 'healthy' may be different for different types of soil.

2.2. So, to enable effective implementation of a strategy and to deliver consistent monitoring and measurement of soil health, there must be a common definition of 'Soil Health'. There is no universal definition but we consider the following as a suitable definition for UK purposes:

'The capacity of the soil to function in order to sustain life'

2.3. Under this definition, a healthy soil can be used productively without adversely affecting its future productivity, the ecosystem or the environment.

2.4. The James Hutton Institute has been working on numerous projects in recent years on the question of soil health and how it might be changing, often in collaboration with partners in the UK, Europe and inter nationally, such as:

- National Soil Inventory of Scotland - resampled in 2006-2011 (www.hutton.ac.uk/about/facilities/national-soils-archive/resampling-soils-inventory), funded by Scottish Government;
- To assess change under afforestation and deforestation, with Forest Research and Cranfield University, funded by Forestry Commission ;

- To develop simple assessments of soil erosion that can be carried out locally by SEPA staff, with SEPA and Scottish Government;
- To produce unified soil maps of the UK, initiated under the UK Soil Observatory funding from BIS, with Cranfield University.

2.5. Under the auspices of the UK Soil Indicators Consortium led by the Environment Agency (2006) www.gov.uk/government/uploads/system/uploads/attachment_data/file/290729/scho0306bkiq-e-e.pdf), there has been substantial UK research into indicators that could be deployed to measure soil health. Although further work is needed to develop cost-effective, easy to use and rapid methods, **current knowledge is sufficient to establish robust monitoring**. A monitoring programme needs to be based on a combination of physical, chemical and biological indicators based around measurable parameters. It must also operate within the framework of a sampling baseline and ongoing strategy for monitoring, reporting and interpreting change. Approaches to monitoring will increasingly combine innovative methods including remote sensing, smartphone technology and hand-held sensors, all supported by traditional field surveying and soil characterization.

2.6. Remote sensing techniques include satellite, airborne and unmanned aerial vehicle (UAV) sensors. The new suite of ESA Sentinel satellites is of particular interest, and offers improved opportunities for ready access to medium-level spatial resolution imagery (10m). Radar (Sentinel-1) can provide imagery even in cloudy conditions, and below the vegetation canopy, while multispectral imagery (Sentinel-2) provides information on vegetation as indicators for soil contamination, moisture content, and inherent fertility. Access to Sentinel data products will increase over the next 2 to 5 years.

2.7. There is a need for rapid, reliable and reproducible approaches for determining components of soil biodiversity. In the Defra document 'Safeguarding our soils' (Defra, 2009 www.gov.uk/government/publications/safeguarding-our-soils-a-strategy-for-england), biodiversity is mentioned as something that soils support, but it should be recognised that the reverse is also true, as habitats have characteristic soil biodiversity which in turn reflects the soil functional capacity.

2.8. The requirements for a national soil monitoring programme were set out by Black et al. (2012 www.environment.scotland.gov.uk/media/59999/Soil_Monitoring_Action_Plan.PDF). Past initiatives based on traditional soil survey approaches (e.g. Loveland et al., 2002) need to be incorporated into a more flexible approach that can capture data gathering activities across different organisations and approaches; organisations already undertake field visits as part of their statutory roles to which value can be added. This could help address a gap in updating soil information. It is also very important that the monitoring has distinct objectives that relate to specific soil functions and/or policies and that there are pathways to transfer results of monitoring activities to stakeholders.

2.9. The Scottish Soil Monitoring Action Plan (MAP) is a first step towards a broader integrating approach (Scottish Government 2012, www.gov.scot/Resource/0048/00482106.pdf) which includes investigations into citizen science in soil monitoring (Baggaley et al., 2014 www.sniffer.org.uk/files/2814/0291/8541/DP02_Soils_and_Citizen_Science_Final_Report_June_2014.pdf).

What are the benefits that healthy soils can provide to society?

3.1. Soil is a valuable but vulnerable part of our natural capital and provides many often unseen benefits. These benefits are recognised in some existing strategies, for example 'Safeguarding our Soil: A Strategy for England' (Defra, 2009) and the Scottish Soil Framework (Scottish Government, 2009 www.gov.scot/resource/doc/273170/0081576.pdf), where a number of high level soil functions and their maintenance are key components. When soil and associated functions are degraded or lost, it can take several decades to restore or re-establish useful functioning soil; the costs of doing so (in terms of restoration and loss of functions in the intervening time) are significantly in excess of the short-term value gained from unsustainable management. Soils are complex systems and it is this complexity that has given them a degree of resilience without which we would already be experiencing even more serious issues.

3.2. Soil functions are similar to ecosystem services, which explicitly have benefits to society. The UK National Ecosystem Service Report (2011) recognises the fundamental need for healthy soils in the delivery of ecosystem services:

'*Soil quality is linked to almost all other regulating services (e.g. nutrient cycling, biomass production, water quality, climate regulation, pollination, etc.) through the soil's capacity to buffer, filter and transform'* (page 80, Synthesis Report).

This Report also states:

'*The condition of many soils in the UK – absolutely fundamental to continued productivity and support of biodiversity – is considered degraded, mainly because of atmospheric deposition and inappropriate management*' (page 10, Synthesis Report).

3.3. The benefits of healthy soil to society are already well recognized by the FAO (www.fao.org/globalsoilpartnership/en/) and the recently published Status of the World's Soil Resources (www.fao.org/documents/card/en/c/c6814873-efc3-41db-b7d3-2081a10ede50/). The soil functions and associated benefits listed in the Scottish Soil Monitoring Action Plan (Black et al., 2011) cover those relevant to the UK. These are:

- providing food, wood and biomass production;
- controlling and regulating environmental interactions;
- regulating water flow and quality;
- storing carbon and maintaining the balance of gases in the air;
- providing valued habitats and sustaining biodiversity;
- preserving cultural and archaeological heritage;
- providing raw materials (including new medical products);
- providing a platform for buildings and roads;
- human and animal health;
- human health and wellbeing from urban green spaces, and from working the soil and growing food in allotments.

3.4. For the above benefits, it is important to understand that soils are different from one another and have different primary functions/values. There is a lack of contemporary monetary and non-monetary valuation of soil to society but it is well established that soils are essential to society and have high values (Banwart, Noellemeyer and Milne eds., 2014

www.soilcarbon.org.uk/volume71.html). Comprehending and quantifying the less obvious benefits is vital in making the case for investment in soil health.

3.5. Glenk et al. (2010 www.sepa.org.uk/media/138663/socio-economic_data_soils.pdf) provided a comprehensive overview of the socio-economic impacts associated with a number of soil pressures. Key findings were: (a) difficulties in sourcing robust economic data directly related to soil, and (b) the majority of costs associated with poor soil health were off-site (e.g. water and air quality, above ground habitats, human health, built infrastructure).

3.6. Sustainable soil management is a key component in the delivery of a suite of societal benefits; poor soil management can hamper that delivery and in extreme cases produce catastrophic outcomes and result in a range of levels of conflict between involved parties.

What are the consequences of failing to protect soil health for the environment, public health, food security, and other areas?

4.1. The consequences are reductions in the benefits outlined above and in some circumstances (e.g. urban expansion), their entire loss. A healthy soil is the result of appropriate and sustainable soil management and there are many examples of past civilizations that have suffered due to poor soil management (www.sciencemag.org/content/342/6158/565.full).

4.2. We run the risk of failing to learn from these past experiences, with consequences that will have significant economic impacts. These include:

- Reduced ability to produce food, fibre & biomass for a growing population, putting increasing stress on national economies and global markets;
- Reduction in biodiversity and loss of associated benefits;
- Increased rainfall run-off and increased risk of flooding;
- Reduced ability of soils to buffer environmental pollution;
- Increased erosion and the transfer of minerals, soil carbon, nutrients and pollutants to rivers, lakes and oceans;
- Reduced ability to handle future environmental, political and societal challenges.

What measures are currently in place to ensure that good soil health is promoted? And what further measures should the Government and other organisations consider in order to secure soil health?

5.1. Numerous initiatives are in place and have been implemented to promote good agricultural and environmental soil management, but these generally rely on voluntary principles and opt-in from practitioners. From the summary in the UK NEA (2011), these initiatives appear to have had limited success. Examples include:

- the Scottish Government's Farm Soils Plan (www.gov.scot/resource/doc/47121/0020243.pdf);
- a number of articles on DEFRA's website (e.g. www.gov.uk/guidance/soil-management-standards-for-farmers) ;
- advice from agencies (e.g. www.snh.gov.uk/land-and-sea/managing-the-land/soils/carbon-management/);

- advice with specific objectives (e.g. www.sruc.ac.uk/downloads/file/648/practical_guide_-_improving_soil_quality);
- advice from NGOs (www.soilassociation.org/LinkClick.aspx?fileticket=OqHhW2Cjj44%3D&tabid=313).

5.2. Part of the requirements for farmers to receive the Single Farm Payment is through Cross Compliance and maintaining soils in Good Environmental and Agricultural Condition (GAEC). Precise requirements vary across the UK but the main objectives are to maintain soil organic matter and prevent erosion. However, GAEC is not about promoting soil health in a wider context, soil health is not just a local issue, and the SFP and GAEC do not have relevance to all environments (e.g. forests and urban areas).

5.3. There are few statutory measures that explicitly address soil health or protective measures. Examples are: sewage sludge to land, which is regulated by statute; prime agricultural land in Scotland has some protection from new development; and, new woodlands are not allowed to be established on peat over 45 centimetres deep. These are applied in specific contexts and there remains a lack of an overarching framework for managing and monitoring soil health.

5.4. Some of the wider influences on soil health are not directly associated with soil-specific actions. For example, a major factor in soil health since the 1990s has been action to reduce atmospheric pollution (acid rain and then nitrogen deposition). The approach of the "Terrestrial Umbrella" used by Defra for atmospheric pollution was successful and could be applied more widely. This approach brought relevant organisations together to coordinate on monitoring, managing and mapping, supporting policy and providing guidance on the issues of atmospheric pollution. A similar approach to promote effective soil use and management and to address diffuse pollution has not led to equivalent monitoring or specific guidance on what to achieve in soil health.

5.5. Consideration is needed regarding who pays for public as well as private goods and services (monetary and non-monetary). Since many benefits from, and impacts on, soils are off-site there needs to be appropriate interventions to encourage the land owner / manager to manage soils for wider benefits e.g. water quality improvements, flood control or storage of carbon to mitigate climate change. Recent peatland restoration initiatives are an example of how this can progress. However, continuing difficulties in meeting the Water Framework Directive through effective soil use and management illustrate how challenging this will be.

5.6. Government should also give additional support to the delivery of:

- Information resources to stakeholders in easy to read and easy to apply language;
- Freely available and accessible soil information and data with appropriate explanations to broaden its use among stakeholders.

5.7 Good progress has been made in the provision of such information over recent years (www.soils-scotland.gov.uk/, www.ukso.org/) but much is based on legacy data. A soil monitoring strategy with new data collection would ensure these data remain fit for purpose as well as informing of any changes in soil health.

5.8 Lastly, since soil health is cross-sectoral, there has to be some overarching "champion" body, independent of sectoral interests, that can ensure that soil health is not only managed for single-stakeholder benefits.

What role (if any) should soil health play in the Government's upcoming 25 year plan for the natural environment?

6.1. Soil is the basis of life on Earth. It is vital to our future and should be included in all plans that relate to management of ecosystems and the environment. This is true regardless of whether specific objectives of these plans come from an agricultural, biodiversity, climate change or water quality perspective. The UKNEA (2011) raised awareness of the essential and irreplaceable role of soils in supporting many ecosystem goods and services. Many government policies and international obligations (e.g. Aichi, IPCC, Water Framework Directive) cannot be met if soils are not explicitly included in land, ecosystems and freshwater management. Therefore it is essential that soils are a clear component of the 25 year plan for the natural environment.

6.2. We believe that carbon should be a part of a UK's natural asset/audit register, which would raise the status of soil for all interested parties, including the general public.

6.3. Soil's underpinning of multiple ecosystem services means that impacts on soil should be considered in relation to a wide range of management activities. A particularly relevant recent example is that of flooding in the UK; there is growing scientific consensus on the relationships between soil management and increased runoff. Leaving arable soils bare and devoid of vegetation over winter leads to loss of valuable topsoil during flood events. Strengthening the importance of soils within land management legislation and planning would reduce the cost of damage and improve resilience to future flooding.

6.4. Multiple pressures exist on the ability of soils to sustain societal and economic wellbeing. Promoting solutions based on sound science and building upon the momentum of the UN International Year of Soils 2015 is key to this. Encouraging sectors other than environmental regulatory bodies to consider the importance of soil and potential impacts on its health should be encouraged.

6.5. There is a need for continued investment in fundamental and applied soils research and in the training and education of a new generation of soil scientists and the diversity of skills that this encompasses. In addition to adapting new technologies to the challenges of monitoring soil health, it is important to retain field-based and laboratory skills as these provide baseline information that often cannot be obtained in other ways.

Additional Reference

- Loveland, P.J., Thompson, T.R.E., Webb, J., Chambers, B., Jordan, C., Stevens, J., Kennedy, F., Moffat, A., Goulding, K.W.T., McGrath, S.P., Paterson, E., Black, H. and Hornung, M. (2002). Identification and development of a set of national indicators for soil quality. R&D Technical report P5-053/2/TR, Environment Agency, Swindon 2002).

January 2016