# Natural Capital Committee

**Advice on soil management**

**May 2019**

# Contents

# Introduction

## Context

This paper sets out a brief introduction to the UK's soils and the ecosystem services derived from them. It provides a summary of the current state of the UK's soils, the measures currently in place to protect them, the steps that can be taken to improve their condition, and how those changes can be evaluated using a set of metrics for assessing soil natural capital. The paper then briefly considers how future developments could help strengthen soil monitoring and governance, before making recommendations for protecting and improving soil natural capital. These recommendations are made in consideration of the broad goals of the 25 Year Environment Plan (25 YEP).[1] Despite stating the aspiration to manage our soils sustainably by 2030, the 25 YEP does not provide a soils strategy for England. This paper repeats the call in the NCC's sixth annual report to give soils greater focus and attention equivalent to air and water.[2] Although the NCC refers to and considers the whole of the UK in this paper, its recommendations are limited to the English environment in accordance with its terms of reference.

## The value of our soils and pressures upon them

Soils are critical to human existence. Their role in food production is clearly recognised but their important role in wider ecosystem services including climate regulation, flood risk reduction and water purification is less recognised. Soils also provide support for buildings, landscapes and heritage as well as opportunities for engagement with the natural environment. It takes an average of 100 years to generate 1cm of topsoil; thus soil should be considered as a non-renewable resource and managed accordingly. A quarter of the earth's biodiversity including earthworms, fungi and bacteria resides in soil. The complex interaction between these organisms maintains its fertility and structure with additional benefits such as provision of antibiotics.[3]

However, soils are being degraded globally resulting in external costs equivalent to 17% of global GDP,[4] with an estimated cost between £0.9 billion and £1.4 billion per year for England and

[1] 25 YEP goals: Clean air; Clean and plentiful water; Thriving plants and wildlife; Reducing the risks of harm from environmental hazards; Using resources from nature more sustainably and efficiently; Enhancing beauty, heritage and engagement with the natural environment; Mitigating and adapting to climate change; Minimising waste; Managing exposure to chemicals; Enhancing biosecurity.

[2] Natural Capital Committee, *State of Natural Capital Annual Report 2019* (2019): https://www.gov.uk/government/publications/natural-capital-committees-sixth-annual-report

[3] 50% of new antibiotics are from soil which is especially pertinent considering the global challenge of antimicrobial resistance, identified as a 'catastrophic threat' by the Chief Medical Officer.

[4] Initiative, E. The value of land: Prosperous lands and positive rewards through sustainable land management (2015): http://www.eld-initiative.org/fileadmin/pdf/ELD-main-report_08_web-72dpi_01.pdf

Wales.[5] The primary degradation processes globally are erosion, salinization, intensification of farming and soil sealing.[6] Within the UK the rate of soil erosion is estimated to be 10-100 times higher than it has been prior to intensive farming, with 2.2 million tonnes of soil eroded each year.[7] Soils underpin the many landscapes that support outdoor recreation where >80% of natural capital value comes from.[8] Additionally, cereal yields have flat lined over the past 20 years with soil degradation identified as one of the causes.[9]

Peatlands are UK Biodiversity Action Plan priority habitats. These habitats vary in extent from 22,000 square kilometres (blanket bog) to 250 square kilometres (fens).[10] UK peatlands are estimated to store approximately three billion tonnes of carbon, but they are under pressure.[11] Only 1% of England's deep peats have been mapped as being in an undamaged state. The main degradation drivers are: grazing, managed burning, atmospheric deposition, drainage, agriculture, afforestation and peat extraction.[12]

In the urban environment soil sealing from construction is degrading soils, disconnecting them from the wider environment so they cannot support plants and trees which provide the inputs to support soil biodiversity. Sealing also prevents water percolation into soil, so flood risk is increased. Urban soils are also impacted by legacy contamination which puts the health of people and wildlife at risk.

## Current state of soils

The Countryside Survey (CS) is an 'audit' of the natural resources of the UK's countryside and has been conducted in 1978, 1998 and 2007.[13] The CS soil component measured: carbon content, bulk

[5] Graves et al., *The total costs of soil degradation in England and Wales*, Ecological Economics, (2015): https://www.sciencedirect.com/science/article/pii/S0921800915003171

[6] Soil sealing is the covering of soil by impermeable materials e.g. concrete, tarmac etc.

[7] Posthumus, H., Deeks, L. K., Rickson, R. J. and Quinton, J. N., *Costs and benefits of erosion control measures in the UK* (2015). Soil Use Manage, 31: 16-33. https://onlinelibrary.wiley.com/doi/abs/10.1111/sum.12057

[8] ONS, *Natural Capital* (accessed 2019): *https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/naturalcapital*

[9] FAO, *Prospects by major sector* (accessed 2019): http://www.fao.org/3/y3557e/y3557e08.htm

[10] RSPB, *Peatlands (accessed 2019)*: https://www.rspb.org.uk/our-work/our-positions-and-casework/our-positions/agriculture-and-land-use/farming-land-use-and-nature/peatlands/

[11] IUCN, *Peatlands and Climate Change* (2009) http://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/images/091201BriefingPeatlands_andClimateChange.pdf

[12] Natural England, *England's peatlands: carbon storage and greenhouse gases (NE257)* (2010): http://publications.naturalengland.org.uk/publication/30021

[13] Countryside Survey (accessed 2019): https://countrysidesurvey.org.uk/

density, pH, nitrogen, mineralizable N (i.e. that potentially available for plant uptake), Olsen P (determines phosphate release from soil), and metals (primarily the toxic elements).[14] Soil carbon increased between 1978 and 1998, then declined to 2007, but only significantly in arable land.[15] Furthermore, Cranfield University compared data from the National Soil Inventory of England and Wales undertaken in 1978 and resampled in 2003, and reported that carbon was lost from soils across England and Wales over the survey period at a mean rate of 0.6% $yr^{-1}$.[16] The National Ecosystem Assessment 2011 also noted that most land classes had declining soil quality.[17]

Across England 70% of peatlands show on-the ground degradation. Almost a quarter of deep peat area is cultivated, including almost 40% of lowland fen peat.[18] Lowland peatlands are among the most productive soils in England and are responsible for supplying a large proportion of our domestic salad production. However, this productivity is not sustainable. Cultivated peatlands are losing about 1-2 cm of soil depth every year, contributing an estimated 7 $MtCO_2e/yr$ to UK greenhouse gas emissions, and ultimately leading to complete loss of the peat and greatly reduced agricultural productivity.[19] This rate of loss is predicted to get worse with future climate change scenarios. The Environmental Audit Committee identified the loss of soil carbon from these cultivated peatlands as one of the greatest threats to soil security in the UK.[20] To address these issues the International Union for the Conservation of Nature has developed a UK Peatland Strategy which aims to restore 95% of peatlands by 2040.[21]

Artificial surfaces covered 8% of the UK in 2012, but the rate of change has increased from 0.21% during 2000-2006 to 1.00% during 2006-2012.[22] There is a paucity of data available for the impacts

[14] Countryside Survey, *Soils* (accessed 2019): https://countrysidesurvey.org.uk/content/soils

[15] Countryside Survey, *Countryside Survey: Soils Report from 2007* (2007): http://www.countrysidesurvey.org.uk/sites/default/files/CS_UK_2007_TR9-revised%20-%20Soils%20Report.pdf

[16] Bellamy, P. H et al., *Carbon losses from all soils across England and Wales 1978 – 2003* (2005) https://dspace.lib.cranfield.ac.uk/bitstream/handle/1826/3326/Carbon%20losses%20from%20all%20soils%20across%20England%20and%20Wales%201978-2003.%202005.pdf?sequence=1&isAllowed=y

[17] Austen et al,, *National Ecosystem Assessment 2011* (2011): https://uknea.unep-wcmc.org

[18] Natural England, *England's peatlands: carbon storage and greenhouse gases (NE257)* (2010): http://publications.naturalengland.org.uk/publication/30021

[19] Natural England, *England's peatlands: carbon storage and greenhouse gases* (2010): http://publications.naturalengland.org.uk/publication/30021

[20] Environment Audit Committee, *Soil carbon and climate change* (2016): https://publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/180/18006.htm

[21] IUCN, *UK Peatland Strategy 2018 - 2040* (2018): http://www.iucn-uk-peatlandprogramme.org/resources/uk-peatland-strategy-2018-2040

[22] Colea et al., *Acceleration and fragmentation of CORINE land cover changes in the United Kingdom from 2006–2012 detected by Copernicus IMAGE2012 satellite data* (2018): https://lra.le.ac.uk/bitstream/2381/42740/4/1-s2.0-S0303243418301314-main.pdf

of soil sealing on soil biodiversity and soil ecosystem services and this is a pressing research need. There are 325,000 potentially contaminated sites across England and Wales with the majority of these sites linked to previous waste disposal by landfilling. The Environment Agency's evaluation finds that the uncertainties are too great to estimate the effect of these sites on human health.[23]

## Current protection measures

Despite the clear importance of soils, they are virtually ignored when compared to issues such as air quality, water quality and biodiversity - either in terms of statutory protection, government policy attention, or public interest. Preventing further deterioration, restoring land and conserving biodiversity are central to achieving the Sustainable Development Goals (SDGs) and the UN commitment land degradation neutrality.[24] England, Wales and Scotland have all signed up to the SDGs so they offer a starting point for a UK wide soil management policy.

In the 2009 publication 'Safeguarding Our Soils: A Strategy for England' Defra first outlined its aspiration that soil should be managed sustainably by 2030.[25] Four key aspirations were identified:

- Agricultural soils will be better managed and threats to them will be addressed;
- Soils will play a greater role in the fight against climate change and in helping us to manage its impacts;
- Soils in urban areas will be valued during development, and construction practices will ensure vital soil functions can be maintained;
- Pollution of our soils is prevented, and our historic legacy of contaminated land is being dealt with.

In the 2011 Natural Environment White Paper,[26] government recognised the natural capital asset of soils and reiterated the aspiration that by 2030 all of England's soils should be managed sustainably and degradation threats tackled successfully. However, the only firm commitment was to undertake a significant research programme to explore how soil degradation can affect the soil's ability to support vital ecosystem services. It is not possible to fully assess if this was

[23] Defra, *SP1002 Appendix 3 Estimation of the overall risk to human health from contaminated land* (2011): http://sciencesearch.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=16185

[24] United Nations: https://www.unenvironment.org/

[25] Defra, *Safeguarding our soils: A strategy for England* (2009) https://www.gov.uk/government/publications/safeguarding-our-soils-a-strategy-for-england

[26] Defra, *The natural choice: securing the value of nature* (2011): https://www.gov.uk/government/publications/the-natural-choice-securing-the-value-of-nature

achieved or what the outcomes from this programme were, but an evidence review for Defra[27] concluded that the valuation of soil ecosystem services was underdeveloped.

In 2015, the Committee on Climate Change recommended the creation of a comprehensive action plan by the end of 2016 to deliver the policy aspirations outlined above. Identified entry points to improved protection were Environmental Stewardship, and cross-compliance conditions that claimants of direct payments (e.g. Basic Payment Scheme) must meet under the Common Agricultural Policy. The protection and maintenance of soil organic matter is a key requirement of the Basic Payment Scheme and the need to maintain land in Good Agricultural and Environmental Condition (GAEC). Farmers claiming the Basic Farm Payment must protect soil by maintaining a minimum soil cover (GAEC 4); minimising erosion (GAEC 5); and maintaining good levels of soil organic matter (GAEC 6). These minimum standards replaced the requirement to complete and retain a Soil Protection Review (SPR) as part of a more 'outcome-focused' approach.[28]

Managing authorities (Devolved Administrations and Defra for England) also have higher level agri-environment schemes, which promote more positive actions for soils such as: reduction in soil erosion (Environmental Stewardship, England); fertiliser reductions and peatland restoration (Glastir, Wales); securing carbon storage in soils (Agri-Environment Climate Scheme, Scotland). However, these programs only relate to agriculture, whilst soil under all land uses needs to be considered.

The new Countryside Stewardship scheme includes a range of measures which have benefits for soil such as winter cover crops, stubble management, woodland creation and grazing management.[29] However, there is no measure that specifically proposes improving soil health, instead this is an anticipated outcome from measures such as those listed above. This 'light touch' approach, particularly in England, is further evidenced by the fact that not all agricultural land falls under the Basic Payment Scheme and therefore is not covered by the GAEC rules. Finally, farm scrutiny is challenging because of the low numbers of inspectors relative to farm holdings, with limited enforcement action and few prosecutions reported.

Human health is protected from soil pollution by the Part 2A of the Environment Act 1990 where land has not been remediated via planning consent, or voluntarily under the polluter pays principal. Local authorities have the primary responsibility to identify potentially contaminated sites and to finance remediation where the polluter cannot be found. The capital support grant for clean-up of sites was withdrawn by Defra in 2017, with the use of the broader Revenue Support

[27] See: http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=16992

[28] Defra, *Agricultural soil protection: incentives and regulations* (2016): https://publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/180/18007.htm

[29] Defra, *Countryside Stewardship: Higher Tier Manual* (2019) https://www.gov.uk/government/publications/countryside-stewardship-higher-tier-manual

Grant proposed by Defra as a funding mechanism. With pressure on local authority budgets it is unlikely that polluted sites will be actively identified and remediated in the future.

The National Planning Policy Framework (NPPF) states that the planning system should protect and enhance soils and prevent development from contributing to unacceptable levels of soil pollution. Local planning authorities must assess the economic and other benefits of the best and most versatile agricultural land. Poorer quality land should be used in preference to that of a higher quality and the re-use of brownfield sites is encouraged. Once the decision has been taken to develop an area of land, it is important to retain as many healthy soil functions as practicable by careful management of the soils during construction. Protection of geodiversity is also highlighted but there is no specific reference to soil diversity.[30]

Within the COP21 treaty ratified in Paris by the UK government is the '4 per 1000 initiative'. This arises from a calculation that an annual growth rate of 0.4% in the soil carbon stocks, or 4‰ per year, would halt the increase in the $CO_2$ concentration in the atmosphere related to human activities.[31] This is not possible in all soils but is a positive step to restoring soil health as well as combating climate change.

The 25 YEP restates the aspiration to manage our soils sustainably by 2030 but does not provide a soils strategy for England. Soils are complex. The EU Soils Framework Directive failed because of the incompatibility of land management policies across partner countries.

The 25 YEP aims to restore soil fertility, reverse degradation, support beneficial practices and underpin potential future government support. There is also a commitment in the 25 YEP to improve the way we manage and incentivise land management, including designing and delivering a new environmental land management system. This will be underpinned by the development of a soil health index. The plan also re-iterates the Defra commitment to end the use of peat in horticulture by 2030. However, the means of achieving these aspirations has not been developed.

## Beneficial practices for soils

It is widely recognised by soil scientists that managing soil organic carbon (C) is central to optimising soil function because organic matter influences numerous soil properties supplying ecosystem services. Even small changes in soil C content can have disproportionately large impacts on key physical and biological properties of soil. Beneficial practices include conversion from arable to grassland or woodland, retention of crop residues and application of organic matter such as farmyard manure. However, these practices need to be set against the need to provide food and whether farmers have access to organic materials.

[30] MHCLG, *National Planning Policy Framework* (2012): https://webarchive.nationalarchives.gov.uk/20180608095821/https://www.gov.uk/government/publications/national-planning-policy-framework--2

[31] Soil Association, response to *Building a Zero Carbon Economy – Call for evidence* (2019): https://www.theccc.org.uk/wp-content/uploads/2019/04/Soil-Association-response-to-Call-for-Evidence-2018.pdf

Minimum tillage is practiced in many areas of the world within conservation agriculture. The main driver for this system globally is reduced water losses, but it has other advantages such as reduced soil erosion, improved structure for crop growth and water infiltration and enhanced soil biodiversity. Another benefit is a reduction in the use of farm machinery thereby reducing fuel usage and soil compaction. There is some debate regarding whether minimum tillage increases carbon sequestration; in damp environments this may be offset by increased emissions of nitrous oxide (a powerful greenhouse gas) from soil microbes. Additionally, minimum tillage systems often require the use of chemical weed killers and these need to be replaced by physical approaches e.g. use of rollers.

The use of cover crops - i.e. grown but not harvested - can build soil fertility, increase organic matter, reduce soil erosion and moderate nutrient losses. A wide range of crops can potentially be used depending on the management system. For example, a mix of species with different root architectures and rooting depths can be used to improve soil structure and mop up excess nutrients.

Restoration of peats is primarily achieved by blocking field drains to restore the water table providing the saturated conditions required for formation. Other options include removing forestry, preventing burning or reseeding. In receptive zones restoration can be achieved in 2-5 years.

## Metrics

Soil natural capital can be separated into inherent (texture, orientation, slope) and manageable (carbon content, porosity, pH) properties.[32] To build the value of the assets, practices that have beneficial impacts upon the manageable properties need to be encouraged. Defra is currently developing a suite of metrics to evaluate the progress of the 25 YEP, which will be reported on annually. Soil health will feature in this framework. Most studies propose some combination of chemical, physical and biological measurements to evaluate soil health. Defra has funded several reports to identify which metrics should be used and where[33] but is still developing a soil health index which will be linked to the aspirations of the plan.

Soil metrics are required for three purposes:

1. To observe slow changes in soils to support natural capital accounts and the work of the Office for National Statistics (ONS);[34]
2. To underpin the payments for public goods if this replaces pillar 2 of the CAP;

[32] Dominati et al., *A framework for classifying and quantifying the natural capital and ecosystem services of soils. Ecological Economics* (2010): https://www.sciencedirect.com/science/article/pii/S0921800910001928?via%3Dihub

[33] See e.g.: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/290729/scho0306bkiq-e-e.pdf

[34] See: https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/naturalcapital

3. To provide simple indicators for farmers to improve their land.

The diversity of soils is seen as a barrier to providing a single set of metrics, but the perfect should not be the enemy of the good. When asked, soil scientists quickly agree that a mix of physical, biological and chemical indicators are required. The most frequently cited are:

1. Bulk density – for soil structure, compaction, water storage (flood risk) and risk of nitrous oxide production (an important greenhouse gas);
2. Soil pH – important for biomass production, water quality and biodiversity;
3. Soil organic carbon – measured to 15 cm - important for carbon sequestration, crop nutrition and soil stability;
4. Soil N – important for biomass/crop production and potential risk to water quality, nitrous oxide production and plant biodiversity;
5. Soil P – important for biomass / crop production and potential risk to water quality.

Carbon is the primary metric to target to begin the process of improving soils; it is central to soil function as it sustains biological activity while providing nutrition and conditions for crop growth. Soil carbon is used as an ecosystem health indicator by Scottish Government and a wellbeing indicator by the Welsh Government. Additionally, there is industrial interest in C sequestration for the purpose of offsetting and policy engagement through the 4 per 1000 initiative. Care is required regarding just how much C soils can retain, but operational envelopes can be developed.

Surveys of stakeholders can quickly inform adaptation of soil health indicators to the local context. For example, a mixed group of practitioners, policy makers and researchers proposed organic matter, water retention, earthworms, structure and microbial diversity for intensive agriculture. In urban systems microbial diversity was replaced by contaminant loading while for peatlands a new suite was required (depth, carbon stock, drainage status, plant community and pH).[35]

Linking soil processes from the aggregate to the landscape scale is currently not possible, even within simulation models. However, if we can encourage individual famers to adopt best practice the cumulative effect at the landscape scale will be significant with considerable economic benefits including reducing the silting of rivers, preventing flooding, removing nutrients and pesticides and storing carbon while reducing GHG emissions. In a number of areas clusters of farmers are forming to achieve such benefits.

[35] British Ecological Society, S*oil health* (2016): https://www.britishecologicalsociety.org/wp-content/uploads/BES-Soil-Health-response-2016-FINAL..pdf

## Future developments

### Monitoring

Spectral methods[36] are rapid and require minimal processing, hence do not incur excessive cost. They can operate from the soil ped scale (i.e. hand grab sample) to determine chemical properties, through to the field scale with drones, and satellite imaging to identify specific crops in fields. For example, the Africa Soil Information System supported by the Gates Foundation has processed 80,000 samples to calculate land capability.[37] This approach is now being developed in smart phone apps which could operate for individual farmers assisting their management decisions by allowing more targeted inputs, with GPS tagging of such data supporting environmental stewardship payments. Such a dynamic application will address soil heterogeneity experienced across individual farms.

High throughput DNA sequencing allows for the rapid characterisation of microbial genes to determine the function of the soil microbiome. Recent research indicates the structure of the microbial community is more important than diversity or abundance of species, when diverse data sets were combined from international studies.[38]

### Partnerships

Broad stakeholder partnerships can provide for stronger governance and improve soil health within a wider environmental system. The Catchment Sensitive Farming initiative supported 13,000 holdings achieving improvements in soil health and a 30% decrease in pollutant loadings in water courses.[39] The Midwest Row Crop Collaborative brings together practitioners, regulators and the food supply chain to improve water quality and soil health with an aspiration to reduce nutrient concentrations in water bodies by 45% before 2035.[40]

[36] Spectroscopy is a method for accurate analysis of multiple soil content properties and can be implemented both rapidly and inexpensively.

[37] Rothamsted Research, A global spectral library to characterize the world's soil (2016): https://www.rothamsted.ac.uk/soil-spectral-lab

[38] Bünemann et al., Concepts and indicators of soil quality – a review (2016): https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5ae63cb0e&appId=PPGMS

[39] Natural England, *Catchment Sensitive Farming Phase 3 Delivery Report Update (CSF158*) (2017): http://publications.naturalengland.org.uk/publication/4570556294234112

[40] Midwest Row Crop Collaborative (accessed 2019): https://midwestrowcrop.org/about-us/

### Land protection

The National Trust and Crown estates are both exploring tenancy agreements which stipulate that soils should be left in a healthy condition upon the expiry of the agreement putting pressure on the tenant not to adopt short term soil management practices.

## Recommendations

- Government should give soils equivalent focus and attention to air and water and this should be reflected in the 25 YEP indicators being developed, such that soil health is one of the headline indicators. To underpin this investment in developing soil indicators should go well beyond the £200,000 specified in the 25 YEP and reflect the cost of ongoing degradation which is estimated at £3.21 billion just for the loss of soil carbon across the UK.
- The protection and enhancement of soil quantity, quality and health should be incorporated into any future environmental land management scheme to encourage beneficial practices. These include those that reduce climate change, increase biodiversity, avoid soil erosion and increase water holding capacity.
- A national survey should be undertaken as part of the NCC's proposed environmental census[41] to determine the state of soils in England, with periodic updates every five years to ensure our soils are being restored. The survey should start where sites are most degraded e.g. peats and arable land.
- A comprehensive suite of policies and funded actions to ensure soils are managed sustainably by 2030, as outlined in the 25 YEP, should be developed following the survey. These will need to align with post Brexit agricultural payments for public goods.
- In addition to a comprehensive national survey, an assessment of sites where soils have been sealed by development (e.g. in urban environments) should be undertaken and government should commit to not increasing the level of soil sealing in line with environmental net gain principles[42] and ensuring sustainable soil management.
- When developing their peat management strategy the upcoming Lowland Peat Taskforce for England should adopt and support the recommendations of the International Union for Conservation of Nature (IUCN) Peatland Strategy.

[41] The NCC's Sixth Annual Report calls for an environmental census to establish a robust baseline against which to measure progress towards the 25 YEP goals: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/774218/ncc-annual-report-2019.pdf

[42] The principle of 'environmental net gain' aims to drive measurable improvements for all aspects of the environment such as air quality, flood defences and clean water.

- The capital grants for the remediation of contaminated sites by local authorities should be re-instated. This will reduce the pollutant load in urban areas with potential to improve human and ecological health.