

Environmental Audit Committee – Inquiry into Soil Health

Written Submission from the Committee on Climate Change – 14th January 2016

1. The Committee on Climate Change (CCC) was established under the 2008 Climate Change Act. We advise the Government on carbon budgets and report to Parliament annually on progress towards meeting the 2050 target of an 80% reduction in UK greenhouse gas emissions. The Adaptation Sub-Committee (ASC) of the CCC advises the Government on the risks from climate change and reports to Parliament every two years with an independent assessment of the progress being made with preparing the UK for a changing climate.

Importance of soils

2. The depth, volume, amount of organic matter, and quality of soil, are all of critical importance for the productive capacity of agricultural land. Erosion and loss of soil organic matter reduces yields and imposes additional production costs such as increasing the need for fertiliser or irrigation.

3. Soils are also of critical importance for both climate change mitigation and adaptation:

- **Carbon storage and GHG emissions** - an estimated 10 billion tonnes of carbon are stored in UK soils. This dwarfs the 0.2 billion tonnes stored in UK vegetation. Where soils are degraded, a proportion of the stored carbon is emitted to the atmosphere as CO₂. Nearly 4% of UK greenhouse gas emissions in 2013 were due to losses of soil carbon – a total of 22.5 million tonnes CO₂ equivalent.¹ These emissions were higher than for many industrial and energy sources, for example petroleum refining (14.7 MtCO₂e), concrete production (6 MtCO₂e) and the chemical industry (5.2 MtCO₂e).
- **Water attenuation** - UK soils store an estimated 130 trillion litres of water, much more than are contained in all the UK's lakes and rivers combined. Soils in good condition help to slow the water cycle through infiltration of rainwater, and so play an important role in managing flood risk. Degraded and compacted soils can have the opposite effect, exacerbating flood risk by increasing the speed of rainwater run-off and silting up rivers.
- **Water quality** - soil erosion and loss of carbon has adverse impacts on water quality. Around 5% of rivers, lakes and estuaries in England do not currently meet good ecological status due to sedimentation. High carbon content in drinking water supplies can also create carcinogenic by-products that can potentially make the water unfit for human consumption.

Risks to soils from climate change

4. Soils are highly sensitive to climatic conditions. Projected increases in rainfall volume and intensity are likely to change soil weathering rates and increase susceptibility to water erosion. At the same time, reduced soil moisture content and increased aridity as a result of higher average temperatures and changes in rainfall patterns will make soils more vulnerable to wind erosion and lead to an increased demand for irrigation. Sea-level rise will increase brackish water encroachment on lowland coastal areas, leading to soil salinization.

¹ Total UK GHG emissions in 2013 were 570.5 MtCO₂e. Emissions of CO₂ from soil carbon losses are recorded in the Land Use, Land Use Change and Forestry (LULUCF) section of the UK GHG Inventory and breakdown as follows: 12.4 MtCO₂ from croplands, 3.5 MtCO₂ from grasslands and 6.1 MtCO₂ from development. In addition to emissions from soil carbon losses, some 20 MtCO₂e is emitted from the way soils are managed. This results from a range of factors such as the application of fertiliser and grazing from livestock and is primarily in the form of nitrous oxide (N₂O). These emissions are recorded in the Agriculture section of the UK GHG Inventory.

5. Warmer and drier conditions in the future are likely to accelerate the decomposition of organic matter and so exacerbate losses of soil carbon. This could have implications for the viability of upland peat habitats, especially blanket bogs. Some models suggest that the area of suitable climate for peat forming vegetation in the uplands could decline in extent by between one-half and two-thirds by the 2050s. However, paleo-ecological evidence stretching back over 9,000 years shows that peat forming vegetation has adapted to warming periods in the past. This suggests that when peat habitats are in a good condition they can potentially continue to form peat even under warmer and drier climatic conditions.

6. The vulnerability of soils to the impacts of climate change has been exacerbated by patterns of land use and management in England over the last 50 years or so. This is particularly the case for arable and upland soils.

- **Arable soils** have been subject to increased mechanisation, the use of agrochemicals and synthetic fertilisers, and the introduction of new crop varieties such as maize. Many strategically important areas for arable production are reliant on continued pump-drainage, being located in low-lying land that in some places are well below current sea-levels.
- **Upland soils** were extensively drained in the 1950s/1960s and large swathes of moorlands are regularly burnt for grouse shooting. As well as land management, almost all upland soils are adversely impacted by air pollution in the form of nitrogen and ammonia deposition from energy, transport and agricultural emissions. The legacy of the industrial revolution means that many upland soils suffer from heavy metal contamination.

Trends in soil health – Soil Organic Carbon levels

7. The available evidence suggests that soil organic carbon (SOC) levels have been declining nationally in arable soils. The Countryside Survey for England reported a decrease in SOC of about 3 grams per kilogram per year in arable soils between 1978 and 2007.² The decline in SOC is primarily explained by changing land management practices, including:³

- **Reductions in the spreading of animal manure** – as a result of the steady decline in livestock numbers and the intensification of livestock production leading to the production of liquid slurry at the expense of farm yard manure.
- **More efficient removal of crop residues** -due to technological improvements in harvesting machinery and the replacement of traditional hay cropping with silage production.
- **Deeper ploughing depths** - due to increases in tractor power and improved cultivation apparatus, leading to increased mineralization of carbon and dilution of SOC levels.

8. There have been marked declines of SOC in the most carbon-rich arable soils, particularly lowland peats. The National Soil Inventory reported a decrease in SOC on organic arable soils of over 5 grams per kilogram per year between 1978 and 2003.⁴ This is putting at risk some of the most productive land in England as lowland peat soils make up a significant proportion of Grade 1 and Grade 2 agricultural land. Peat soils tend to be very fertile and provide a comparative advantage for intensive high-value cropping, including vegetables, salads and horticulture.

9. The largest single area of lowland peat soils in the UK is the East Anglian Fens, covering around

² Carey, P.D. et al. (2008) Countryside Survey: UK headline messages from 2007.

³ Smith et al (2007) *Climate change cannot be entirely responsible for soil carbon loss observed in England and Wales, 1978-2003*. *Global Change Biology*, 13.

⁴ Cranfield University (2013) National Soil Inventory Database.

130,000 hectares. The Fens account for around 10% of the national area of agricultural land given over to potatoes, sugar beet and vegetable production. Only 34,000 hectares remain as deep peat (i.e. over 0.4 metres in depth). The remaining peat soils in the Fens are now classed as 'wasted' following years of degradation, shrinkage and loss. Almost all of the area is dependent on continued pump drainage, as much of the landscape is now below sea-level following centuries of farming-induced subsidence.

10. The loss of peat soils in The Fens has been occurring for hundreds of years. Today, only around 16% of the peat stock recorded in 1850 remains. Arable production on deep peats requires deep ploughing and power harrowing, alongside intensive drainage, in order to achieve fine seedbeds. The rate of peat loss has been between 10mm to 30mm a year.⁵ Climate change is expected to accelerate these losses, with every 1°C rise in temperatures increasing the rate of loss by 30%.⁶ As a result, all the remaining deep peat soils in the Fens could be lost within the next few decades. The continuation of intensive cropping on peat soils also has a high price in terms of CO₂ emissions. The drainage of UK organic soils for arable and intensive grassland production currently results in emissions of 5.2 MtCO₂ a year.⁷

11. In the Fens and other areas of lowland deep peats, it would be possible for some form of agricultural production to continue in ways that conserve the peat resource. Reverting from intensive arable systems to extensive wet grasslands would conserve the peat and not increase CO₂ emissions. Other potentially viable alternatives that would potentially conserve peat are the production of perennial biomass crops and agro-forestry.

Trends in soil health – erosion

12. Actual soil erosion is difficult to monitor over time at the national scale. However, modelling of the factors associated with soil erosion suggests the risk has decreased gradually across all grades of agricultural land since the 1960s. This is primarily due to an increase in the area under low-risk crops. For example, the area of land under oil seed rape, where only one field in 100 is at risk of erosion, doubled between 1988 and 2010. At the same time, the area covered by high risk crops such as potatoes and sugar beet declined by around one-third.⁸

13. There has, however, been a substantial increase in the area of UK land under the high-risk crop of maize, from 27,000 hectares in 1988 to 196,000 hectares in 2014. Of this, the majority (93%) was grown in England. A survey of over 3,000 sites in south-west England found that the soil structure of three-quarters of fields under maize were damaged to the extent that rainfall is unable penetrate the upper soil layers, resulting in silt-laden run-off during periods of heavy rainfall.⁹

Trends in soil health – upland peats

14. The English uplands are dominated by blanket bog and heathland habitats, which tend to have highly organic and peaty soils. When in good condition, peat bogs actively soak up carbon, accumulating between 3 and 7 tonnes per hectare per year. Peatlands also play a vital role in the

⁵ See ASC (2013) *Managing Land in a Changing Climate* for references.

⁶ Graves, A. and Morris, J. (2013) for the ASC.

⁷ 1.7 MtCO₂e from drainage of organic soils for croplands and 3.5 MtCO₂e from drainage of organic soils for grasslands. Source: UK GHG Inventory.

⁸ 1 field in 10 of potatoes and 1 field in 7 of sugar beet are at risk of erosion. Cranfield University (2015) for the ASC.

⁹ Palmer, R.C. and Smith, R.P. (2013) Soil structural degradation in SW England and its impact on surface-water run-off generation. *Soil Use and Management*, 29 Issue 4

provision of drinking water to millions of people, as they form the headwaters for some of England's major water supply catchments.

15. England's upland peat habitats are widely degraded. A survey by Natural England in 2012 estimated that some 144,000 hectares (51%) of blanket bog habitat has completely lost its mossy, peat-forming vegetation.

- **40,000 hectares (14%) are eroding.** In these areas, deep channels have formed that can often erode down to the mineral soils under the peat. Gully erosion can eventually undermine the remaining vegetation and leave a landscape of bare peat. Vegetation loss can also result from severe wildfires. Bare peat is eroded by rain, frost heave, and wind, with much of the eroded peat soil being carried into rivers and reservoirs.
- **50,000 hectares (18%) has been drained.** Shallow ditches (known as 'grips') have been cut across significant areas. The grips drain water more quickly away from the mossy surface, which thins or disappears completely as the water table lowers.
- **76,000 hectares (27%) are regularly burnt.** Burning is used to promote a mosaic of heather of different ages. Heather is the preferred habitat for red grouse, the primary upland game bird. There are approximately 140 grouse shooting estates in the English uplands, with an average size of 2,000 hectares. Managed burning is also used to cut fire breaks in order to reduce the spread of wildfire

16. The area of burned moorland has increased significantly in recent decades across much of northern England. A comparison of aerial photography from the 1970s and 2000 of over 200 km² of the English uplands found that the extent of new burns had doubled (from 15% to 30%) over this period. A recent study found that the annual number of burns between 2001 and 2011 increased by 11% per year, with an accelerating trend in more recent years.¹⁰

17. There is increasingly strong evidence that managed burning reduces peat accumulation, causes declines in carbon storage, and increases dissolved organic carbon (DOC) levels in watercourses.¹¹ Levels of DOC in UK upland water bodies have doubled over the last 30 years. Some of this observed increase in DOC is likely to be due to reductions in sulphur deposition (more commonly known as acid rain) since the 1990s. However, there is evidence that managed burning is the primary cause of DOC export in parts of the English uplands.¹²

18. Degraded peatlands can be restored, through measures such as blocking drainage ditches, re-seeding bare peat and reducing adverse management practices such as intensive burning and over-grazing. There is increasing evidence from field studies that restoration reduces carbon losses, both as CO₂ and DOC, as well as delivering biodiversity and landscape benefits.¹³ A number of water companies operating in the English uplands have been investing in peatland restoration in recent years to help reduce the carbon content in raw water, and therefore lower the costs of drinking water treatment.

¹⁰ Douglas et al. (2015). *Vegetation burning for game management in the UK uplands is increasing and overlaps with soil carbon and protected areas*

¹¹ Natural England (2013) *Effects of managed burning on upland peatland biodiversity, carbon and water* NEER 004.

Brown, et al (2014) *Effects of Moorland Burning on the Ecohydrology of river basins*. University of Leeds.

¹² Clutterbuck and Yallop (2010) *Land management as a factor controlling dissolved organic carbon release from upland peat soils*. *Science of the Total Environment* 408, 6179–6191

¹³ See ASC (2013) *Managing the land in a changing climate* for references.

Response to specific inquiry questions

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

There is currently no systematic monitoring of key trends in soil health at the UK or England level. Key metrics of soil health exist that could be tracked, such as SOC levels, CO₂ emissions, DOC levels in water bodies, etc. The uptake of soil conservation measures could also be monitored.

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

As noted above, soils provide fundamental societal benefits beyond just their importance for agricultural production. From a climate change perspective, the key benefits of healthy soils are storing carbon, alleviating flood risk and improving water quality.

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

Some of the adverse consequences of poor soil health for climate change mitigation and adaptation are discussed above. Protecting soil health will become ever more difficult with climate change.

4. *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?*

Announced in 2009 and reiterated in the 2011 Natural Environment White Paper, the Government has set a policy ambition that all soils will be managed sustainably by 2030. This is an ambitious goal and an aspiration that we fully support.

In our recent advice to Government for the 5th Carbon Budget we identified a range of cost-effective measures that farmers could implement that could deliver both GHG emissions savings and improvements in soil fertility/quality. These include amongst other things, measures to increase the efficiency of fertiliser use, loosen soil compaction, and the use of catch and cover crops.

There is a number of existing policy interventions that provide farmers with some incentives to improve soil health. These are primarily based on the Common Agricultural Policy (CAP). In theory, farmers must provide minimum soil cover, take measures to prevent erosion, and maintain soil organic matter levels in order to qualify for the full single farm payment. However, in practice the low levels of inspection make it difficult for these requirements to be enforced.

Voluntary agri-environment schemes funded under Pillar II of the CAP are also important mechanisms for encouraging soil conservation, although soil health is not a priority objective of the new Countryside Stewardship Scheme. The Catchment Sensitive Farming programme led by the Environment Agency also provides advice and capital grants to farmers to reduce soil erosion. However, this initiative only covers a relatively small area of total agricultural land, being focussed on around 80 key catchments, and has a very small budget to fund capital works.

In the uplands, Natural England has been working with the Upland Stakeholder Forum to produce a

blanket bog restoration strategy, although this has not yet been published. As noted above, water companies in the uplands are also delivering restoration schemes, with an estimated £45 million invested between 2010 and 2015. However, the amount of restoration that will be delivered over the next five years is unclear, as individual schemes are not specified within water company business plans for the new Asset Management Plan period (AMP6, 2015-2020).

Despite these actions, the on-going declines in soil carbon, increases in the area of some high erosion risk crops (e.g. maize) and the degraded condition of upland peats suggests that current policy interventions will not deliver the 2030 aspiration for all soils to be sustainably managed.

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

The CCC recommended in both its 2015 statutory progress report to Parliament on reducing emissions and in our 5th Carbon Budget advice that stronger policies may be required to deliver emissions reduction consistent with the Committee's estimates of the cost-effective path to 2030. For certain measures such as increasing the efficiency of fertiliser use, this would also deliver a beneficial impact on soil health. Although these measures are feasible to implement, securing their wider uptake would need to be underpinned by a strong policy framework that goes beyond information and advice as is currently the case in England with the voluntary approach of the GHG Action Plan.

The ASC recommended in its 2015 statutory progress report to Parliament that Defra should publish an action plan within a year describing how the goal of all soils being sustainably managed by 2030 will be achieved. The action plan should:

- establish a scheme to monitor the uptake of soil conservation measures, with enforcement where soils are not being appropriately managed; and
- include specific proposals to reverse the on-going loss of lowland peat soils.

In its response, the Government stated that *"we are considering how the development of the framework for the environment could support the implementation of this recommendation but are not able to make any announcements on this at this stage"*.¹⁴ We therefore expect to see the Government's forthcoming 25 year environment plan set out the specific measures that will be taken to meet the policy goal of all soils being sustainably managed by 2030 and beyond.

Further information

A summary of the CCC and ASC 2015 progress reports to Parliament can be found [here](#). The ASC's 2015 report can be found [here](#), where chapter 5 of the report covers Agriculture & Forestry and Chapter 6 the Natural Environment. More detailed technical annexes to both chapters, which contain the range of data underpinning the ASC's analysis, can be found [here](#).

¹⁴ HMG (2015) Government Response to the Committee on Climate Change