

Environment, Food and Rural Affairs Committee Call for evidence: Soil Health

Authors: Andrew Tye, Darren Beriro

Organisation: British Geological Survey

The British Geological Survey (BGS) is a world leading applied geoscience research centre, which provides objective and authoritative geoscientific data, information, and knowledge to inform Government on the opportunities and challenges of the subsurface environment.

BGS has a dedicated soils team whose current areas of focus include work on soil formation and erosion (Soil lifespans), the link between soil moisture, shallow groundwater and crop yield, soil contamination and transfer of contaminants to humans and within ecosystems.

1. How can the Government measure progress towards its goal of making all soils sustainably managed by 2030? What are the challenges in gathering data to measure soil health how can these barriers be overcome?

To measure progress towards sustainable soil management, UK soils need to be monitored to:

- determine if they remain suitable to perform their required functions (e.g. food and fibre production, regulating water supplies, maintaining biological habitats, sources of raw materials, recreation and cultural heritage);
- check soil health;
- measure the success of implementing policy interventions (e.g. to increase soil carbon storage), and
- quantify threats to e.g. to ecosystems and humans from soil contamination.

BGS has undertaken collaborative research commissioned by Defra and the Welsh Government, proposing design options for a UK soil monitoring network [1] and considering innovative approaches to monitoring soil health in England and Wales [2]. This work recommends that any soil monitoring program should include purpose-built networks of sites where soil properties are periodically measured across three spatial scales following sound scientific principles to ensure that the networks lead to reliable, unbiased and representative results:

- National-scale surveillance networks to provide estimates of the status and rate of change of soil health indicators and their variation in space;
- Regional-scale monitoring targeted to sites of interest, such as habitats that are sensitive to changes in soil properties, valuable natural capital such as peatland or where threats to soil health or land use change could be expected to impact soil health.
- Localised experimental platforms are required to test the impact of climate change or changes to land management practices to soil health and explore the effectiveness of novel measurement technologies [1,2].

Challenges:

Establishing soil monitoring networks requires a substantial financial investment and commitment to long term network support and management over several decades [3,4]. Costs arise from the

collection and laboratory analysis of soil samples from across the UK, the management and analysis of data and the archiving and storage of soil samples. Archiving is required for additional analysis needed to address emerging soil issues post network establishment. For example, the Environment Agency has commissioned BGS to explore whether archived soil samples can be used to establish a baseline of concentrations of Per- and polyfluoroalkyl (PFAS) substances in soil. The water-resistant properties of these chemicals have led to many practical applications since the mid-twentieth century but their persistence in the environment is leading to increasing concern.

Adopting new measurement technologies e.g. sensors mounted on satellites, aircraft or land vehicles could reduce the cost of soil monitoring and acquire data at a greater spatial and temporal resolution than soil monitoring. For example, recent work undertaken by BGS and UKCEH has examined the use of high-resolution aerial photography (plane and satellite imagery) to assess soil erosion and disturbance across Wales [5]. In many contexts the sensed data have been found to be highly correlated to laboratory measurements [4,6], but whilst sensor and satellite technologies could provide a greater spatial and temporal span they should only be used to supplement, rather than replace, conventional monitoring efforts. Generally, these sensors measure soil properties related to the property of interest rather than that property itself and although these relationships between measured and sensed soil properties are currently applicable, they might diverge upon changes to soil conditions [7].

Soil information can also be acquired from laboratory analyses of soil samples collected for land management practices (e.g. soil nutrient assessments for agriculture [8]) or from mathematical models of soil variation. Again, this knowledge should only supplement conventional monitoring because land management sampling is likely to be biased towards locations of interest and mathematical models can only approximate the status of the environment.

The integration of these different data sources presents computational challenges. The impact of each data source on reported estimates of soil health need to be weighted according to its reliability and associated uncertainty at the national-scale. This requires novel statistical and machine learning techniques and extensive computational resources to run at the national-scale. Mathematical models of soil variation are computationally intensive, with the ownership and licencing of different soil datasets restricting how they can be used and in stored. The Robinson report [2] suggested data could be integrated within virtual data laboratories. Currently, Digital Twins of the environment are a major focus of UK Research and Innovation funding. Mark Gaskarth, Head of the EPSRC Theme for Digital Twins, defined them as virtual replicas and representations of assets, processes, systems, or institutions in the built, societal, or natural environments [9]. A Digital Twin of national-scale variation of soil properties could be an ideal framework to manage the integration of knowledge regarding the variation of soil health and functionality and run mathematical models of soil variation whilst respecting the licencing of different soil data products. Such a Digital Twin could iteratively validate knowledge on soils and propose modifications to the models or identify locations where additional measurements are required. Additionally, dashboards could communicate the derived information regarding soil health and functionality to a range of stakeholders and decision makers.

2. Do current regulations ensure that all landowners/land managers maintain and/or improve soil health? If not, how should they be improved?

N/A

- 3. Will the standards under Environmental Land Management schemes have sufficient ambition and flexibility to restore soils across different types of agricultural land? What are the threats and opportunities for soil health as ELMs are introduced?**

N/A

- 4. What changes do we need to see in the wider food and agriculture sector to encourage better soil management and how can the Government support this transition?**

N/A

- 5. What does UK Government need to do to tackle other stressors on soil health such as soil contamination?**

BGS has undertaken surveys and modelling work in relation to both legacy industrial and urban contamination and also in relation to the transfer of contaminants (mainly macronutrients) from agricultural land to surface and groundwaters.

Soil contamination in urban areas is commonly considered a constraint to development by regulators (LPAs, EA, UKHSA), developers, investors, Government (local, regional and national) and other stakeholders. This relates to long term exposure to chemical contamination and impacts on present human health and environmental risks [10]. Where these risks are considered unacceptable based on existing or new land uses, risk management and remediation can be costly and, in some cases, cost prohibitive. Contaminated soils are often present on 'brownfields' – which at their broadest level are sites that have been affected by their former land use, are derelict and often underused or subject to a change of use [11].

Brownfields are often well located for redevelopment and have or are close to existing urban infrastructure [12]. Rather than viewing contaminated soils as a constraint and a risk, the remediation of contamination should be considered by Government as a vehicle for achieving sustainable development and place-making. Soil is a natural capital asset linked directly to the provision of ecosystem services such as carbon storage, attenuation of surface water run-off, and supporting ecologically diverse habitats. [13]. There are also indirect benefits associated with quality urban soils including being a key component of providing recreation and accessibility to green space, with the associated physical and mental health benefits of being connected to such areas.

A step-change is required to move from considering contaminated soils as a constraint to an opportunity to create sustainable places to live and work. BGS suggest some of the key actions are required to help make this happen:

- Reimagine brownfields and potentially contaminated soils as a system of systems challenge, characterising and quantifying causal links between soils, place making and sustainable development.
- Create a shared digital evidence base of the extent of potentially contaminated soils and brownfield land – the current Brownfield Land Registers are focused only on potential housing sites and are inherently limited in scope and scale. Rethinking a common approach at a Local Authority scale for a range of land uses would provide an inventory against which to measure, monitor and manage potential net gain from remediation and would help provide more targeted deliverables [13,14].

- Focus on the links between contaminated soils as a natural capital asset and the environment, social, economic benefits that can accrue from them when remediated and bought back into beneficial use [15].
- Use and where required create innovative land use data-driven digital models and tools to measure, monitor and manage the benefits that accrue from healthy urban soils [16,17].

A further area of concern is that of the nitrate ‘timebomb’ and BGS have been active in describing this link between agriculture and long-term groundwater aquifer quality [18]. This is one of the linkages explored by BGS between soil contamination and groundwater. Soils may exist as temporary sinks for many contaminants, and poor management will lead to poor soil health. Poor management will likely result in accumulation and leakage of contaminants to other ecosystems or landscape compartments. Thus, the success of questions 2, 3, and 4 in this consultation will partly be reflected in improvements of air, surface and groundwater quality as part of improved soil health and management.

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