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1. Introduction and background

To secure essential soil ecosystem services (SES) the importance of soils must be recognised and priorities defined, reflecting their specific properties and how they are used. Western and upland areas of the UK are dominated by permanent grasslands, peatlands and moorlands, with drier areas in the east dominated by cultivated land. The predominance of agriculture (c. 70% of land surface) and the diversity of soil and climatic conditions have influenced UK soil threats and priorities. An increasing urgency to mitigate and adapt to climate change has meant a new direction for land use and soil management, with plans to protect and enhance peatland, increase the area of woodland and sequester additional carbon in mineral soils.

2. UK soil threats and priorities

2.1 Soil degradation

The main soil degradation processes of concern across the UK are compaction, erosion and soil organic matter (SOM) loss. Damage to soil structure can arise from suboptimal field operations and livestock grazing, particularly when wet. Extended livestock grazing seasons, late-harvested crops and increasing machinery weight are of concern.

Soil water erosion is the dominant erosive process, with light arable soils at greatest risk. In the uplands, thin soils and deep peats are most sensitive. Recent research suggests that 16% of incidents measured on arable land were greater than 1 t ha^{-1} yr^{-1}, with a maximum 92 ha^{-1} yr^{-1} associated with catastrophic events such as landslides. Large declines in SOM have been reported from past UK soil surveys, particularly on arable soils in England and are attributed to land use change (i.e. deforestation or conversion of grass to arable). Together, soil compaction, erosion and loss of SOM was

estimated to cost £1.2 billion a year in England and Wales in 2015, and can be mitigated through several sustainable soil manage

2.2 Soil nutrient management

Agricultural intensification has resulted in disruption of the soil nutrient cycle across the UK. While there is a nutrient surplus in livestock areas such as the north-west and Northern Ireland (NI), arable areas in the south-east are highly reliant on imported nutrients. Consequently, there has been an unsustainable build-up of soil nutrients in livestock regions, in contrast to a decline on arable farms. For example, Bateman et al (2011) reported that the north-west of England has a phosphorus surplus of +2.9k tonnes while the south-east had a deficit of -14.4k tonnes. Priorities to help address these issues include embedding nutrient management planning on farms while providing a framework for beyond-the-farm gate management of manure within and between UK regions.

2.3 Soil contamination and sealing

Soil contamination can increase soil acidity and toxicity of compounds with severe impacts on food production, soil biodiversity and functions reliant on microbes. The total area of contaminated land in the UK (England & Wales, Scotland, NI) is estimated at 405,000 ha. Contamination mainly affects soils close to urban and industrial areas (e.g. nitrogen, sulphur and persistent organic pollutants), but diffuse contamination spread through water (e.g. nitrate and phosphate) or air (e.g. volatiles, heavy metals and ground-level ozone) can affect other areas (RoTAP, 2012).

Soil sealing removes contact between soil and the environment, threatening the ability of soil to transmit water and air and regulate the climate. Mainly associated with urban areas in the UK, it often coincides with some of the best quality soils. Artificial surfaces covered 8% of the UK in 2012 (Cole *et al*., 2018), with over 22,000 ha of land changed to urban development in 2006-2012.

2.4 Land take and prime farmland protection

Agricultural land take profoundly threatens SES, but receives relatively little attention (Peake & Robb, 2021). England and Wales currently follow the Agricultural Land Classification (ALC) guidelines (slightly adapted by NI) to identify the "best and most versatile (BMV) land" and protect it from development, while Scotland applies its Land Capability for Agriculture for a similar purpose. The UK also affords some protection to farmland through green belt zones and a brownfield first approach, although some of these policies have been progressively diluted and left to the discretion of local authorities throughout most of the UK (Menadue, 2013). In Wales, however, the primacy of ALC and BMV land has largely been maintained.

2.5 Climate change impacts and carbon sequestration

Climate change will increase weather variability in the UK, with higher temperatures and more severe and frequent drough[Journal Pre-proof] loss of SOM has implications for soil functions and resilience to physical or chemical perturbation. In rich organic soils, rapid mineralization of SOM would create a surplus of nutrients, increasing the risks of water eutrophication from soil during intense and prolonged rainfall events, however research shows uncertainty as to whether the UK's soils will predominantly capture or emit carbon (Abdalla, 2016; British Society of Soil Science, 2021).

2.6 Peat restoration

Peatlands are vital stores of carbon, helping to tackle climate change, and also forming the basis for upland farming, sporting activities, tourism and crofting, central to economic sustainability. Peatlands cover 10% of the UK land area (three million hectares) and play a key role in flood regulation, water quality and support internationally important species of high biodiversity value,

Peatlands in their natural waterlogged state accumulate carbon, in the form of peat, at a rate of approximately 1mm a year. However, most of the UK's peatlands are no longer sequestering and storing carbon effectively as many peats are degraded. The UK Peatland Code, a voluntary certification standard, has been formed for UK peatland projects wishing to market the climate benefits of peatland restoration, administered by the International Union for Conservation of Nature.

2.7 Monitoring, mapping and data access

Baseline soil survey data and soil sampling strategies are essential to fully inform multidisciplinary challenges. However, no common UK wide approach exists to soil monitoring, mapping and data access. In Scotland a high percentage of soil data, coupled with water and biodiversity information, are publicly available (SEWeb; sifss). Natural Resources Wales (NRW) has created a unique and publicly available online predictive ALC map, allowing dynamic adjustments for future climate change. NRW is also mapping peat and its associated carbon stocks. The UKCEH Countryside Survey, started in 1978 constitutes the longest integrated UK wide countryside monitoring programme. The UK Soil Observatory provides UK level soils data. High resolution soil geochemistry data are available as part of the NI Tellus Project in addition to a soil nutrient health scheme (SNHS), aiming to map soil nutrient, soil carbon, above ground biomass and runoff risk in NI.

3. UK and devolved responsibilities – policy and practice

The four nations of the UK, England, Scotland, Wales and NI, each have distinct soil types and land use. The UK parliament primarily governs England, while the devolved administrations set most of their own policies and legislation (Figure 1).

Soil classification and survey were incorporated into UK government policy in the 1930s, becoming part of a national strategy 1970s when concerns were raised about soil degradation - erosion, structural damage and pollution (Agricultural Advisory Council, 1970). Soil contamination was addressed to some extent by environmental protection laws and agricultural regulations. In the 1980s concerns over habitat loss, pesticides and biodiversity shifted the agricultural policy emphasis from food production to environmental protection, a trend which continues today.

The UK had no soil policies and only minimal soil-related legislation until the early 21st century, but in 2009 both England and Scotland had soil strategies, indicating a paradigm shift towards SES and climate mitigation. UK governments are committed to the goal of managing all soils sustainably by 2030, exemplified in England's Environmental Land Management (ELM) scheme. A range of similar policies and support schemes are in place across the devolved administrations that, informed by good quality available soil data and associated mapping tools, should help ensure the many different soils are managed in the best way possible for the multiple functions they deliver now and into the future.

Soil science has long been an important discipline in the UK. The British Society of Soil Science (BSSS) plays a major role in professional training, accreditation, and excellence in teaching of soil science at all levels. The BSSS, with other organisations, is committed to the study of soil in its widest aspects and brings together students, academics, practitioners and all those with an interest in soils. This enhanced understanding and engagement with soils is essential for agriculture, landscaping, construction, remediation, conservation and archaeology, as well as influencing policy direction on critical topics such as climate change.

4. Conclusions

UK soil priorities evolved through the twentieth century, becoming an integral part of land evaluation. In later decades, as attention was drawn towards the environmental impact of human activity, there was a growing focus on SES, such as biodiversity, flood control, and on harms inflicted on soil itself. The criticality of soil carbon took on even greater significance in the 1990s when its role in climate change became widely recognised. The urgent challenges of the new century will guide the way the UK prioritises future management and protection of one of our most valuable natural assets - soil.

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References

Abdalla, M., Smith, P., 2016. Agriculture and Forestry Climate change report card technical paper. 2. Climate and soil functions: impacts on Soil processes and properties and future implications in the UK – a review. 131221-NERC-LWEC-AgricultureForestrySource2-SoilFunctions.pdf (ukri.org)

Agricultural Advisory Council, 1970. Modern Farming and the Soil: Report of the Agricultural Advisory Council on Soil Structure and Soil Fertility. HM Stationery Office, London.

Bateman, A., van der Horst, D., Boardman, D., Kansal, A. and Carliell-Marquet, C., 2011. Closing the phosphorus loop in England: The spatio-temporal balance of phosphorus capture from manure versus crop demand for fertiliser. Resources, Conservation and Recycling, 55(12), pp.1146-1153. https://doi.org/10.1016/j.resconrec.2011.07.004

British Society of Soil Science (2021). Science Note: Soil Carbon. Long_BSSS_Science-Note_FOR-DIGITAL-new-logo.pdf (soils.org.uk) The short, summary Note: https://soils.org.uk/wp-content/uploads/2021/11/Short_BSSS_Science-Note_FOR-DIGITAL.pdf

Cole, B., Smith, G., Balzter, H. 2018. Acceleration and fragmentation of CORINE land cover changes in the United Kingdom from 2006–2012 detected by Copernicus IMAGE2012 satellite data. Int. J. Appl. Earth Obs. Geoinf., 73, 107-122.

Menadue, H., 2013. DYNAMIX policy mix evaluation: Conserving rural land in England, Ecologic Institute, Berlin. Land_UK.pdf (dynamix-project.eu)

Peake, L., Robb, C., 2021. Saving the ground beneath our feet: Establishing priorities and criteria for governing soil use and protection. Royal Society Open Science, 8(11). https://doi.org/10.1098/rsos.201994

RoTAP, 2012. Review of Transboundary Air Pollution: Acidification, Eutrophication, Ground Level Ozone and Heavy Metals in the UK. Contract Report to: Department for Environment, Food and Rural Affairs; Scottish Government; Welsh Assembly Government; Department of the Environment in Northern Ireland. Centre for Ecology & Hydrology. ISBN978-1-906698-22-5. https://uk-air.defra.gov.uk/library/reports?report_id=701

Figure 1: Soil policy governance and main soil evidence delivery in the UK

1. Predominance of agriculture in the UK is major factor determining soil priorities.
2. Main soil degradation processes are compaction, erosion and organic matter loss.
3.
4. Agricultural land take threatens soil ecosystem services.
5. Climate change impact has resulted in a new direction for land use and soil policy.

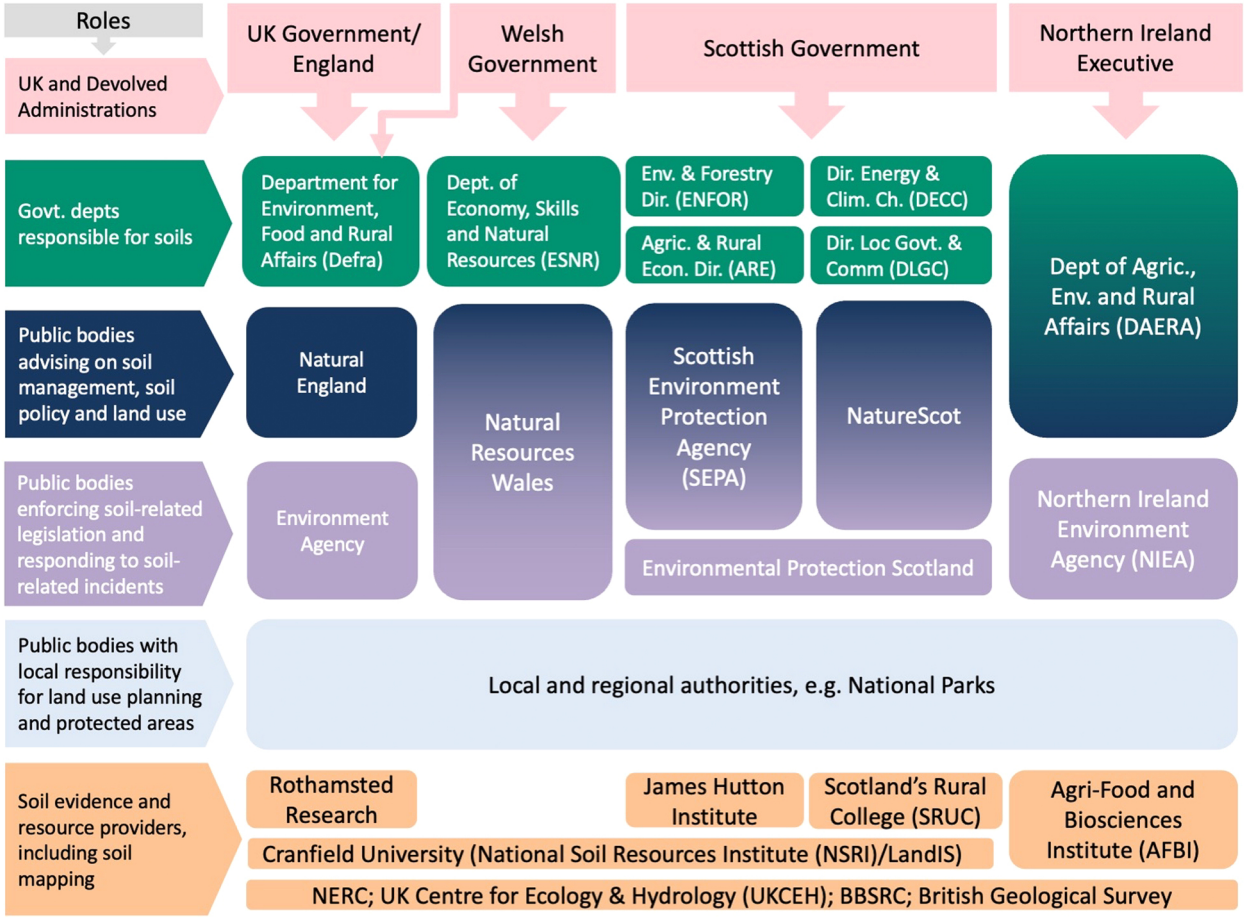
Roles
UK and Devolved Administrations
UK Government/ England
Welsh Government
Scottish Government
Northern Ireland Executive
Govt. depts responsible for soils
Department for Environment, Food and Rural Affairs (Defra)
Dept. of Economy, Skills and Natural Resources (ESNR)
Env. & Forestry Dir. (ENFOR)
Dir. Energy & Clim. Ch. (DECC)
Agric. & Rural Econ. Dir. (ARE)
Dir. Loc Govt. & Comm (DLGC)
Dept of Agric., Env. and Rural Affairs (DAERA)
Public bodies advising on soil management, soil policy and land use
Natural England
Natural Resources Wales
Scottish Environment Protection Agency (SEPA)
NatureScot
Public bodies enforcing soil-related legislation and responding to soil-related incidents
Environment Agency
Environmental Protection Scotland
Northern Ireland Environment Agency (NIEA)
Public bodies with local responsibility for land use planning and protected areas
Local and regional authorities, e.g. National Parks
Soil evidence and resource providers, including soil mapping
Rothamsted Research
James Hutton Institute
Scotland's Rural College (SRUC)
Agri-Food and Biosciences Institute (AFBI)
Cranfield University (National Soil Resources Institute (NSRI)/LandIS)
NERC; UK Centre for Ecology & Hydrology (UKCEH); BBSRC; British Geological Survey

Figure 1