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Securing Scotland's soils in a changing climate – technical report

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1 Executive summary

Soils underpin Scotland's natural capital, providing vital ecosystem services, supporting nature-based solutions and essential for societal wellbeing and Scotland's economic profitability. However, unlike air, water and biodiversity (which all rely on soils) there is no soil-specific policy in Scotland to support the protection, restoration and enhancement of this vital resource. The consideration of soils is fragmented across various nature-based policies and so overarching governance is limited, making the implementation of sustainable soil management strategies challenging to coordinate.

An initial framework was published by ClimateXChange in 2025 as a 'Soil Route Map for Scotland' with preliminary actions for delivering improved soil security across Scottish landscapes and support the delivery of wider nature-based policies in Scotland. It provides six initial, overarching objectives of Lead, Protect, Restore, Enhance, Mobilise and Evidence as a response to address risks to soils and to achieve the vision of 'thriving soils for Scotland's communities, economy and environment' in Scotland's third National Adaptation Plan.

1.1 Key points

The second phase of research explored specific issues under the Protect – Restore – Enhance objectives, with actions that could frame a more sustainable approach to soil management in the following key areas:

- soil sealing and soils in construction
- soil compaction and physical degradation
- chemical and biological soil health
- soils in the private sector
- soil monitoring and metrics

This report presents the underlying research undertaken within this phase to support the design and implementation of a pathway to healthy soils for Scotland.

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Glossary/Abbreviations

Carbon-rich soils	Organo-mineral and peat soils are known as carbon-rich soils. A peat soil is defined in Scotland as when soil has an organic layer at the surface which is more than 50cm deep. Organo-mineral soil or peaty soil is soil which has an organic layer at the surface less than 50cm thick and overlies mineral layers (e.g., sand, silt and clay particles). There is also a relatively rare group of soils in Scotland known as humose soils. These have organic rich layers with between 15 and 35% organic matter. These are mineral soils but also considered to be carbon rich.
Deep peat	Deep Peat is a defined soil type that has at least 1 m of organic horizon. NatureScot use Ramsar Convention's definition of peatland: "Peatlands are ecosystems with a peat deposit that may currently support vegetation that is peat-forming, may not, or may lack vegetation entirely". The Soil Survey for Scotland states that peat should have an organic layer or layers that exceed 50 cm deep from the soil surface and an organic matter content of more than 60%.
Ecosystem services	Ecosystem Services are the direct and indirect contributions ecosystems (known as natural capital) provide for human wellbeing and quality of life. This can be in a practical sense, providing food and water and regulating the climate, as well as cultural aspects such as reducing stress and anxiety. In fact, the vast number of services provided by ecosystems can be categorised into more manageable groups of: provisional; regulating; cultural; and the slightly more ambiguous, supporting services.
Eutrophication	The gradual increase in the concentration of nutrients (e.g., nitrogen and phosphorus) in aquatic ecosystem.
Flood resilience	Reduce the intensity and/or frequency of flood events and severity.
Food security	When all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.
Nature Networks	A Nature Network is a joined-up system of places important for wild plants and animals, on land and in water. It allows plants, animals, seeds, nutrients and water to move from place to place and enables the natural world to adapt to change, providing plants and animals with places to live, feed and breed. Effectively functioning nature networks will connect existing nature rich areas through habitat corridors, habitat 'stepping stones', or habitat restoration areas.
Net zero	A target of completely negating the amount of greenhouse gases produced by human activity, to be achieved by reducing emissions and implementing methods of absorbing carbon dioxide from the atmosphere.
Fourier Transform Infrared (FTIR)	FTIR (Fourier Transform Infrared) spectroscopy is an analytical technique used to identify organic, and sometimes inorganic materials by measuring how they absorb infrared light.
Land Capability for Agriculture (LCA)	Land Capability for Agriculture Classification of land on the basis of its potential productivity and cropping flexibility determined by the extent to which its physical characteristics (soil, climate and relief) impose long term restrictions on its agricultural use.

Land Capability for Forestry (LCF)	Classification of land on the basis of its potential to grow trees and flexibility for growth and management based on a number of factors including soil, climate and topography.
LiDAR (Light Detection and Ranging)	The use of Lasers mounted on special aircraft to carry out high resolution 3D mapping to generate to generate high resolution digital surface models.
Living Lab	User-centred, place-based and transdisciplinary research and innovation ecosystems, which involve land managers, scientists and other relevant partners in systemic research and co-design, testing, monitoring and evaluation of solutions, in real-life settings, to improve their effectiveness for soil health and accelerate adoption.
Organo-mineral soils	Also known as peaty soil. Soils In Scotland, soils with topsoil organic carbon concentrations greater than 35% and less than 50cm thick. The term should not be confused with organic-mineral which is used to denote a highly organic-rich topsoil.
Peat	Peat is a defined soil type that has at least 50 cm organic horizon. The Soil Survey for Scotland states that peat should have an organic layer or layers that exceed 50 cm deep from the soil surface and an organic matter content of more than 60%.
Peatland	Defined by the presence of peat soil or peaty soil types. This means that "peat-forming" vegetation is growing and actively forming peat or it has been grown and formed peat at some point in the past.
Soil acidification	Soil acidification is the lowering of soil pH due to an accumulation of hydrogen ions. Soils with a pH of less than 5.5 is considered 'acidic'.
Soil carbon sequestration	Soils are in constant exchange with the atmosphere, they take in carbon (via photosynthesis, root exudates and the addition of organic material) and release carbon (through gas emissions associated with respiration or indirectly via leaching). Where a net gain in carbon exists, the soils are considered to be 'sequestering' carbon.
Soil classification	Soil classification (also termed soil taxonomy) is the scientific discipline of grouping soils according to similar or comparable soil forming properties and that exhibit a similar sequence of soil horizons. Many countries in the world have national soil classification systems but those of World reference Base and the US Soil Taxonomy are used internationally.
Soil carbon stock	The mass of carbon stored in the soil organic matter per area
Soil compaction	Soil compaction is a form of physical degradation in which soil biological activity and soil productivity for agricultural and forest cropping are reduced, resulting in environmental consequences away from the immediate area directly affected.
Soil contamination	Soil contamination is when soil is polluted, implying the presence of chemicals and materials in soil that have a significant adverse effect on any organisms or soil functions. Soil pollutants include inorganic and organic compounds, some organic wastes and the so-called "chemicals of emerging concern".
Soil degradation	Soil degradation is defined as a change in the soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries.
Soil enhancement	To improve soil health and resilience beyond its current state and the status quo.

Soil erosion	The process of soil being gradually damaged and removed by the waves, rain, or wind, or the result of this process.
Soil function/ functionality	Soil function refers to the six key roles that soil plays in an ecosystem, inc. providing a medium for plant growth, supplying and purifying water, recycling nutrients and organic wastes, serving as a habitat for soil organisms, modifying the atmosphere, and acting as an engineering medium.
Soil health	Healthy soil is a continued capacity of soil to function as a vital living system. Soil is the basis of 95% of our food. If soils are healthy, they provide essential ecosystem services such as clean water and habitats for biodiversity. They are major carbon reservoirs, which help slow the onset of climate change while making us more resilient to extreme climatic events. Soils are a key part of the landscapes that we all cherish and are the basis of our economy and prosperity.
Soil management	A collective term describing a range of practices and applications imposed on soils for a range of purposes (e.g., food production, ground preparation, urban developments, conservation etc).
Soil organic matter	Soil organic matter means all living, or once-living, materials within, or added to, the soil. This includes roots developing during the growing season, incorporated crop stubble or added manures and slurries.
Soil protection	Activities which contribute to the prevention of degradation of soils.
Soil resilience	Soil's ability to buffer or 'cope' with stresses such as extreme weather events and disturbance.
Soil restoration	To 'repair' soils which have been degraded in some way (e.g., physical, chemical or biological degradation).
Soil sealing	The covering of soil (generally with an impermeable material) for the purpose of urban development.
Soil structure	The spatial arrangement of soil particles (called aggregates, crumbs, blocks or peds). Soil structure influences soil functions, for example how water moves through it and susceptibility to degradation such as erosion and compaction.
Visual Evaluation of Soil Structure (VESS)	Visual Evaluation of Soil Structure (VESS) Indicative of the quality of soil structure.
Whole Farm Plan	Under the new Agricultural Route Map for Scotland, farmers and crofters will be required to undertake a series of initiatives as part of a Whole Farm Plan if they wish to apply for support payments through the Basic Payment Scheme (BPS) from 2025 onwards. The initiative has been designed to help farmers and crofters take a holistic view of their farm/croft in terms of efficiency, sustainability, carbon emissions and biodiversity. The idea behind the Whole Farm Plan is to help businesses identify areas for improvement, and to subsequently allow them to assess the effectiveness of the improvements they carried out.
Woodland	Land under stands of trees with a canopy cover of at least 20%, or having the potential to achieve this, including integral open space, and including felled areas that are awaiting restocking (replanting). The minimum area is 0.1 ha and there is no minimum height.
X Ray Diffraction (XRD)	XRD (X-ray diffraction) is a non-destructive analytical technique used to determine the atomic and molecular structure of a material.

Note – sources used to develop the glossary are set out in Appendix A4.

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2 An introduction to Scotland's Soil Route Map

Soils underpin our natural and managed environments and provide vital ecosystem functions such as climate regulation, water storage, productivity and support national biodiversity. Recent policy developments reflect the increasing awareness of soils and the important role they play, particularly in terms of their ability to contribute to climate regulation, flood resilience, food security, support forestry and assist biodiversity.

An initial framework was published by ClimateXChange in 2025 as a 'Soil Route Map for Scotland[1]' with preliminary actions for delivering improved soil security across Scottish landscapes and support the delivery of wider nature-based policies in Scotland. It provides six initial, overarching objectives of Lead, Protect, Restore, Enhance, Mobilise and Evidence (see Table 1) as a response to address risks to soils and to achieve the vision of 'thriving soils for Scotland's communities, economy and environment' in Scotland's third National Adaptation Plan[2]. This addendum report provides results from additional research to identify actions that will support the design and implementation of a pathway for healthier and more resilient soils in Scotland.

Table 1 Initial recommendations presented in the Soil Route Map for Scotland (2025) report.

Objective		**Recommendations**
LEAD	L1	Assemble a 'Soil Policy Team' within Scottish Government
	L2	Update the Scottish Soil Framework
	L3	Review the potential of statutory targets to be introduced and potential alignment with EU Soil Monitoring Law and Nature Restoration Law
Protect, Restore, Enhance	PREn1	Coordinate task groups for shared best practice
	PREn2	Place-based evidence reviews to identify actions needed
Mobilise	M1	Identify existing legal/regulatory avenues for implementing actions for soil protection, restoration and enhancement via implementation plans
	M2	Identify existing and new avenues to implement actions for soil protection, restoration and enhancement via landscape-scale implementation plans
Evidence	Ev1	Baseline soil 'status' across land cover types of Scotland
	Ev2	Identify evidence gaps and future improvement options across different land uses
	Ev3	A Scottish Soil Monitoring Framework
	Ev4	Evidence-led recommendations for future soil protection, restoration and enhancement

[1] A soil route map for Scotland | ClimateXChange (Accessed May 2026)
[2] Scottish National Adaptation Plan (2024-2029) (Accessed May 2026)

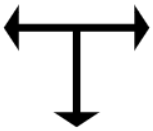
2.1 Steps to implementation

The route map suggests a collaborative, cross-sectoral approach to mobilise Scottish soil security through evidence-led leadership, soil protection, soil restoration and soil enhancement for the future (Figure 1). To achieve this collaborative approach, Objective 2 (Table 1) suggests topic-specific task groups to come together to review and share knowledge and suggest best practice relating to soil protection, restoration and enhancement opportunities for Scotland.

This second report explores this objective in more detail. It examines current policies and practice across 5 topic areas relating to identified risks to Scottish soils presented in the 2025 report and explores how soils can be considered more effectively in policy. The report also considers options to support the implementation of suggested actions within the route map (see section 7) through transferable knowledge, actions and guidance that will co-deliver to multiple policy objectives.

Protect – Restore - Enhance	
PREn1	Coordinate task groups for shared best practice
PREn2	Place-based evidence reviews to identify actions needed

Policy-led approach
Coordination driven by policy themes that soils impact



Risk-led approach
Coordination to address specific risks to soils

Topic Themes	
1	Soil sealing and management of soils in construction
2	Soil compaction and erosion (physical integrity of the soil)
3	Chemical and biological soil health
4	Soils in the private sector
5	Soil metrics and monitoring

Figure 1. Themes identified in the Soil Route Map of Scotland

2.2 Stakeholder engagement

We reviewed policies and scientific evidence across 5 topic themes (Figure 1) to propose further actions for delivery and how these align with policy objectives.

Theme 2 (Figure 1) a workshop with stakeholders was conducted to discuss and collate opinions on the different causes and impacts of soil physical degradation across Scotland and identify potential interventions that could be applied to protect and restore soils. How these activities can support the delivery of policy objectives were also explored (further

details can be found in Appendix C). We also conducted a survey to gather feedback on the route map report published in 2025, which highlighted the importance of cross-sectoral engagement and the need for soil monitoring to support and inform evidence-led recommendations for best practice (further details can be found in Appendix A3).

Sections 2 to 6 of this report provide an overview of each Theme (Figure 1) providing some preliminary suggestions for each task group to consider. Each theme is approached in turn.

3 Soil sealing and management of soils in construction (Theme 1)

This task group could take a broad overview of the challenges around balancing future development pressures and the impacts of soil sealing, particularly with a view to protect high value soils and scope further opportunities to reduce negative implications on soil functions and where possible reuse and recycle soil resources. In addition, the task group will share knowledge on soil 'value' across different land uses, land capabilities and the provision of ecosystem services and nature-based solutions.

3.1 Background

Soil sealing can be defined as the covering of soil with completely or partially impermeable material (e.g. shallow covers like tarmac, paving stones or large concrete permanent structures), with some of the most significant impacts on soil properties occurring as a result of activities associated with construction management (Defra, 2009[3]). Soil sealing negatively impacts soil functions (e.g. its ability to store water) and associated ecosystem services (Appendix B1) and therefore is identified as being a high risk to Scottish soils (Appendix A2) and is a key Landscape Indicator[4] for monitoring changes in Scotland's species, habitats and landscapes.

The challenge is to balance a range of development pressures (for example, housing and energy infrastructure) while protecting soils. The soil route map (2025)[1] proposed the establishment of a task group to examine how high value soils might be better protected from sealing and urban development in the future.

Scotland's 2024 National Planning Framework 4[5] (NPF4) is a long-term plan looking to 2045 that guides spatial development, sets out national planning policies, designates national developments and highlights regional spatial priorities.

Local planning authorities preparing their local development plans (LDP) will be instrumental in taking forward NPF4 across Scotland, each council area responding to their unique challenges and opportunities within their areas of responsibility (Appendix B2). The role of sustainable soils in supporting the delivery of NPF4 policies is set out in Table 2.

[3] Defra (2009) Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (Accessed May 2026)
[4] NatureScot. Scotland's Trends, Indicators and Official Statistics (Accessed May 2026)
[5] Scotland's National Planning Framework (2024) https://www.gov.scot/publications/national-planning-framework-4/ (Accessed May 2026)

Table 2. How soils are related to policies in NPF4 (author's analysis)

NPF4 Policy		Connection to soils
1	Tacking climate and nature crises	Soils are a core component of natural capital
2	Climate mitigation and adaptation	Soil management to conserve soil carbon stores. Ensure soils are a net carbon sink rather than source of GHGs. To ensure soils are managed and protected to mitigate and adapt to the impacts of climate change.
3	Biodiversity	Soils promote nature recovery, adaptation, restoration and resilience. This includes the inherent biodiversity of soils as well as above ground biodiversity that soils support.
4	Natural places	Soils are an important natural asset that should be protected as part of spatial strategies.
5	Soils	Focuses on the protection of prime agricultural land, carbon-rich soils, restoration of peatlands and minimising disturbance to soils from developments.
6	Forestry, woodland and trees	Soils support forest, woodlands and trees.
8	Greenbelt	The protection of greenbelt land contributes to the protection of soil functions.
9	Brownfield, vacant and derelict land and empty buildings	Sustainable reuse of brownfield land such as remediating soil contamination, is likely to have positive implications for soil health and functioning.
10	Coastal development	Sustainable soil management contributes to nature-based solutions that support the resilience of coastal communities.
11	Energy	There's a need to understand the implications and trade-offs renewable energy developments on different soils.
12	Zero waste	Promoting the sustainable reuse of soils and minimising soils going to landfill. Ensuring the application of wastes to land are in line with SEPA regulations (EASR).

More detail on Policy 5 is set out in Appendix B3. Its specific intended outcomes include that (1) valued soils with specific reference to peatlands and carbon-rich are protected and restored, (2) soils are sequestering and storing carbon and (3) soils are healthy and providing essential ecosystem services for nature, people and our economy.

3.2 Key areas of consideration for Theme 1

3.2.1 How are the risks to soils captured in new development applications in Scotland?

Soils are a material consideration for large scale developments at plan and project level through Strategic Environmental Assessments (SEA) and Environmental Impact Assessments (EIA), with more detail set out in Appendix B4.

Guidance, such as Historic Environment Scotland's EIA Handbook (2018)[6], provides direction on the types of soil impacts and mitigation measures to consider with respect to construction, operation and decommissioning. Scotland's Soils Website[7] states that EIA should use available soil information to assess the extent of resources, but that this should also be complemented by more detailed field observations to assess the impact of the development and work out options for restoration or mitigation.

More recently, the Institute of Environmental Management & Assessment (IEMA) Guide: A New Perspective on Land and Soil in Environmental Impact Assessment (2022)[8] provides a framework for identifying and categorising soil-specific receptors, sensitivities and potential impacts. This guidance provides an overarching UK-wide framework to improve and standardise the approach to soils and land use within EIAs and recognises the connectivity of different soil functions. The framework identifies key receptors and soil sensitivities when assessing the potential risks to soils (see Appendix B4).

3.2.2 Protection of Scottish peatlands, carbon-rich soils and prime agricultural land through NPF4

3.2.2.1 Peatlands and carbon-rich soils

NPF 4 states that development on peatland and priority peatland habitats (habitats that are commonly defined by the presence of peat or peaty soil types[9]) and carbon-rich soils will only be supported in limited circumstances, with specified restrictions (Appendix B5). Policy 5d notes that where development is proposed on priority peatland habitats, peatlands and carbon-rich soils, there is a requirement to conduct a detailed site-specific assessment.

NatureScot guidance[10] outlines the surveys to be completed to support achievement of NPF4's policy intentions and mitigation hierarchy and guidance from SEPA is available at Guidance and advice notes | Scottish Environment Protection Agency (SEPA)[11].

In relation to windfarm developments as an example, the National Planning Framework 4: delivery programme V4 (January 2026) report[12] refers to a continuation of the work of the 'Peatland Expert Advisory Group' (established in 2023) to provide advice on managing the development of windfarms on peatland in Scotland. It also signposts recent ClimateXChange research on the process for assessing the potential impact of windfarms on peatland[13] and the reuse of excavated peat soil on wind farm development sites[14]. The latter investigates the opportunities, impacts, and challenges associated with the reuse of excavated peat soil

[6] Environmental Impact Assessment Handbook | Hist Env Scotland (Accessed May 2026)
[7] Planning and development | Scotland's soils (Accessed May 2026)
[8] 2022-iema_land_and_soils_guidance.pdf (Accessed May 2026)
[9] NatureScot Report 701: Scotland's peatland - definitions and information resources (2014) https://www.nature.scot/doc/naturescot-commissioned-report-701-scotlands-peatland-definitions-and-information-resources (Accessed May 2026)

[10] Advising on peatland habitats and carbon-rich soils in development management | NatureScot (Accessed May 2026)
[11] Guidance and advice notes | Scottish Environment Protection Agency (SEPA) (Accessed May 2026)
[12] Supporting documents - National Planning Framework 4: delivery programme V4 - gov.scot (Accessed May 2026)
[13] https://www.climatexchange.org.uk/projects/carbon-calculator-for-wind-farms-on-scottish-peatlands/
[14] https://www.climatexchange.org.uk/wp-content/uploads/2025/08/IQ26-2024-Reuse-of-excavated-peat-on-wind-farm-development-sites.pdf

from windfarm construction sites, providing greater understanding of the current knowledge concerning wind farm development on peatland and carbon-rich soils across Scotland.

3.2.2.2 Prime agricultural land

Policy 5b provides some restriction of developments on prime agricultural land. The term 'Prime' agricultural land refers to land with climate and soil characteristics outlined in classes 1 to 3.1 of the Land Capability Classification for Agriculture (LCA) framework (Appendix B8) and described more fully by Bibby et al (1991)[15].

Anecdotal evidence suggests that in some cases the LCA groupings of 'prime' (LCA Class 1 to 3.1) and 'non-prime' (LCA Class 3.2 to 7) are being misinterpreted as categories of profitability and not in terms of the flexibility of crops that can be supported. An amended phrasing might be useful in the context of planning to avoid misinterpreting or not fully appreciating land potential in a given area. E.g., LCA classes 3.2 and 4 are still suitable for arable production, just for a narrower range of crops.

Mapping Scotland's agricultural capability was undertaken in the 1980's with national (1:250 000 scale) and partial-cover, higher resolution (1:50 000 scale) maps available on Scotland's Soil Website[16]. Research is ongoing (through Scottish Government's Environment, Natural Resources and Agriculture Strategic Research Programme[17]) to explore how digital tools can improve understanding of the impact of climate on Scotland's soils and estimate land capability under future climatic conditions (Udugbezi et al, 2022[18]).

3.2.2.3 Soils in the wider context of NPF4

Appendix B2 outlines the 13 policies included in NPF4's 'Sustainable Places' along with requirements and considerations for LDPs. In addition to Policy 5, sustainable soil management is a core component to many other NPF4 policies shown in Table 2. This becomes more relevant with the increasing focus on integrated land use.

3.2.3 Sustainable management of soils during and post-development

Appendix B9 summarises technical guidance available for the management of soils in the design and construction phases of development, with the majority of Scotland-specific guidance referring to peatland protection. Some local authorities in Scotland, have developed guidance in the form of Soil Management Plans (SMP) for submission alongside planning applications. These refer to Defra's Code of Practice for Sustainable Use of Soils in Construction3, which is not specific to Scottish regulations (in particular the movement of soils on and offsite with respect to Scottish waste regulations, see Appendix B9).

[15] https://www.hutton.ac.uk/wp-content/uploads/2024/05/LAND-CAPABILITY-CLASSIFICATION-FOR-AGRICULTURE.pdf (Accessed May 2026)

[16] https://soils.environment.gov.scot/maps/capability-maps/ (Accessed May 2026)

[17] Environment, natural resources and agriculture strategic research: main research providers - gov.scot (Accessed May 2026)

[18] The Land Capability for Agriculture: building a tool to enable climate change assessments (Accessed May 2026)

3.2.4 Consideration of soils in wider urban context

This report has focused on NPF4 Policy 5. However, soils underpin other aspects of the urban landscape with impacts on soil ecosystem functions, for example, climate and flood mitigation, as outlined in Table 3.

Table 3. Soils in the urban landscape

Urban context	Considerations for Scotland's soils resource
Urban creep	Annual loss of greenspaces due to activities such as paving driveways, building extensions, use of artificial grass and hard landscaping. Leads to cumulative impacts on local drainage, runoff (flood risk) and diffuse pollution. For example, CREW research by Rowland et al (2019)[19] quantified the extent of urban creep in Edinburgh showing that the average annual rate of urban creep (around buildings and their gardens and grounds), between 1990 and 2015 was 6.44ha/year - equivalent to losing over eight football pitches of vegetated land per year.
Recreational	E.g., parks, allotments, sports pitches, golf courses (turf management). Soil compaction and soil stability, drainage and water management, nutrient deficiencies and managing nutrient leaching), thatch management.
Landscaping and engineering	Quality of soil for landscaping (e.g., utilising British Standards). Soil stability and bearing capacity (landslide risk).
Soil reuse	Consideration of both the re-use of soil on construction sites to avoid valuable soil resources going to landfill and the re-use of soil wastes e.g., repurposes excavation waste to produce recycled aggregates and topsoil for construction and landscaping industries.
Green infrastructure	The role of soils in green infrastructure such as rain gardens and constructed wetlands as part of nature-based solutions contributing to climate and flood mitigation strategies.
Urban soils E.g., Management of man-made/ artificial soils	Urban soils are often highly disturbed (e.g., from excavation, filling and grading) with variable composition and may be degraded through compaction and/or contamination depending on the land use and the origin of deposited materials. Therefore, consideration is needed in terms of best practice and potential for re-purposing these soils to optimise the potential ecosystem functions they could offer (e.g., flood management, supporting biodiversity and storing carbon) or to mitigate potential impacts they may have on wider ecosystems (E.g., diffuse pollution and risks to water quality and biodiversity).

[19] https://www.crew.ac.uk/publication/urban-creep (Accessed May2026)

3.3 Options for action for Theme 1

T1-O1. Develop Scotland-specific guidance to support soil protection, restoration and enhancement in Local Development Plans (LDPs)

Soil resources vary across Scotland's local planning authorities (prime soil, peatland, carbon-rich soils, greenfield and brownfield land as well as varied soil types and climatic constraints). Some targeted advice is provided by SEPA and NatureScot, but comprehensive guidance, with an overview on the national extent of different soils and land covers, could include advice on best practice for soil protection, restoration and enhancement within LDPs and SEAs and identify appropriate mitigation to avoid and minimise soil degradation.

T1-O2. Expand guidance for identifying and protecting carbon-rich soils:

The majority of Scotland-specific guidance focuses on peatland habitats. There are opportunities to further support the protection of carbon-rich soils in Scotland i.e., soils that have high organic matter and carbon contents but do not fall within the classification of peatland habitats:

- Clarify and align terminology: NPF4-Policy 5 refers to peatland, priority peatland habitat and carbon-rich soils. Additional terms such as peat as a soil class, organo-mineral and humose soils need to be clarified and used coherently to support effective communication and decision making.
- Develop guidance on best practice: The soils that fit within the category of 'carbon-rich' soils are typically distributed across Scotland's upland, moorland, and heathland environments and commonly interspersed with areas of peat.

T1-O3. Develop targeted guidance for conducting Land Capability for Agriculture (LCA) assessments:

The primary mechanism for identifying land of 'prime' characteristics is through the use of land capability maps and conducting field soil surveys. Updated guidance on how to interpret soil survey data to determine LCA classes would support appropriate application of the LCA classification system relating to prime soils in Policy 5 of NPF4.

T1-O4. Review and develop guidance of soils within EIAs:

Review how potential impacts to soils are assessed in the EIA scoping process to ensure soils are not scoped out the EIA process without due considerations. and explore opportunities to encourage. To accompany this, sustainable soil management proposals should be encouraged for all developments, even where an EIA is not required.

T1-O5. Review opportunities to better link the sustainable management of soils during development projects to support wider environmental net gains:

Sustainable soil management contributes to Scotland's natural capital, supporting range of nature-based solutions and habitats for biodiversity. There are opportunities to better link effective soil management to tangible net gains in ecosystem services and nature resilience. This could include:

- Combine and review research on soil health metrics and benchmarks in the context of the built environment and their applicability to Scotland.

- Review opportunities to progress guidance and tools available to assess soil 'value' to provide further support for informed decision-making in relation to new developments.

T1-O6. Develop procedures which promote the sustainable use and reuse of Scottish soils:

In line with the priority to protect soil, explore and develop procedures to minimise soil disturbance and promote and improve the reuse of valuable soil during developments.

- Further guidance on applying the mitigation hierarchy across different soil systems, i.e., where developments should be avoided (linked to T1-O4), how to minimise disturbance (see below) and appropriate restoration methods across Scottish soils.
- Explore whether there is a need for Scotland-specific guidance relating to the sustainable use of soils in construction (e.g., best practice for soil handling, storage and on-site use/reinstatement of soil during construction)
- Review whether further guidance is needed to support the sustainable reuse of excavated soils in line with Scotland-specific regulation. This support Scotland's Circular Economy and Waste Route Map to 203020 by working with industry to investigate and promote ways to reduce the disturbance and movement of soil and the volumes going to landfill.

4 Soil compaction and the physical degradation of Scottish soils (Theme 2)

4.1 Background

Theme 2 of the route map[1] considers the physical degradation of Scottish soils through compaction. Physical degradation has wide-reaching and cross-sectoral implications that can jeopardise Scotland's environmental goals and impact our communities and economy including on site impacts and the increase in the risk of loss of soils by erosion and landslides. For example, soil compaction can physically restrict root growth and accessibility water and nutrients which can impact the growth of crops and vegetation. Reduced water infiltration and storage leading to increased surface runoff. Changes to water movement through soil leads to

- increased risk of soil erosion
- increased risk of flooding
- exacerbates diffuse pollution
- potential for anaerobic conditions leading to increases in GHG emissions
- Impacts soil biodiversity

These impacts of soil compaction potentially jeopardise Scotland's ambitions across policy themes such as climate change and national net zero targets, food security and agricultural

[20] https://www.gov.scot/publications/scotlands-circular-economy-waste-route-map-2030/pages/5/ (Accessed May 2026)

productivity, flood resilience and water quality as well as Scotland's nature and biodiversity recovery.

A ClimateXChange (2018)[21] report highlights the link between soil compaction and soil erosion. Compacted soils have a restricted capacity to store rainfall compared to soils of the same type that are not compacted, which in turn generates overland flow that exacerbates the risk of soil erosion.

It is estimated that 26% of Scotland's cultivated topsoils are compacted, leading to an estimated loss of yield costing between £16 million and £49 million per year with an additional £9 million to £26 million for increased fuel use (Baggaley et al., 2024[22]). The offsite costs of soil erosion, including the decline in water quality and GHG emissions, were calculated as £21 million and £40 million (if drinking water treatment costs were included). These estimated costs are expected to increase if soil erosion derived from increased runoff due to soil compaction is considered.

The combination of compaction and sealing could lead to a 1% increase in flood area or flood intensity, costing local authorities £2.6 million and each affected home claiming an average £57,000 to £76,000 in insurance per flood event.

Scotland's soil vulnerability (risk) to degradation maps (Figure 2.) Provide a useful tool for assessing appropriate land management with respect to a soils' inherent vulnerability to erosion. This is particularly valuable for landscape-scale management planning and building resilience to risks such as flooding through nature-based solutions. Forests, woodlands and peatlands support climate adaptation and resilience through functions such as flood mitigation, reductions in soil erosion and the provision of shade and shelter against temperature extremes as outlined in Scotland's Climate Change Plan: 2026–2040[23].

As soil compaction is an issue pertinent to all land uses and sectors, this section reviews options to mitigate the key causes of soil compaction and consequential soil erosion. Options for action that enhance the identification and alleviation of physical soil degradation that can be applied across land uses to address soil compaction nationally are explored.

[21] soil-erosion-and-compaction-in-scottish-soils-adapting-to-a-changing-climate.pdf (Accessed May 2026)
[22] Assessing the socio-economic impacts of soil degradation on Scotland's water environment | CREW | Scotland's Centre of Expertise for Waters (Accessed May 2026)
[23] https://www.gov.scot/publications/scotlands-climate-change-plan-2026-2040-annexes/ (Accessed May 2026)

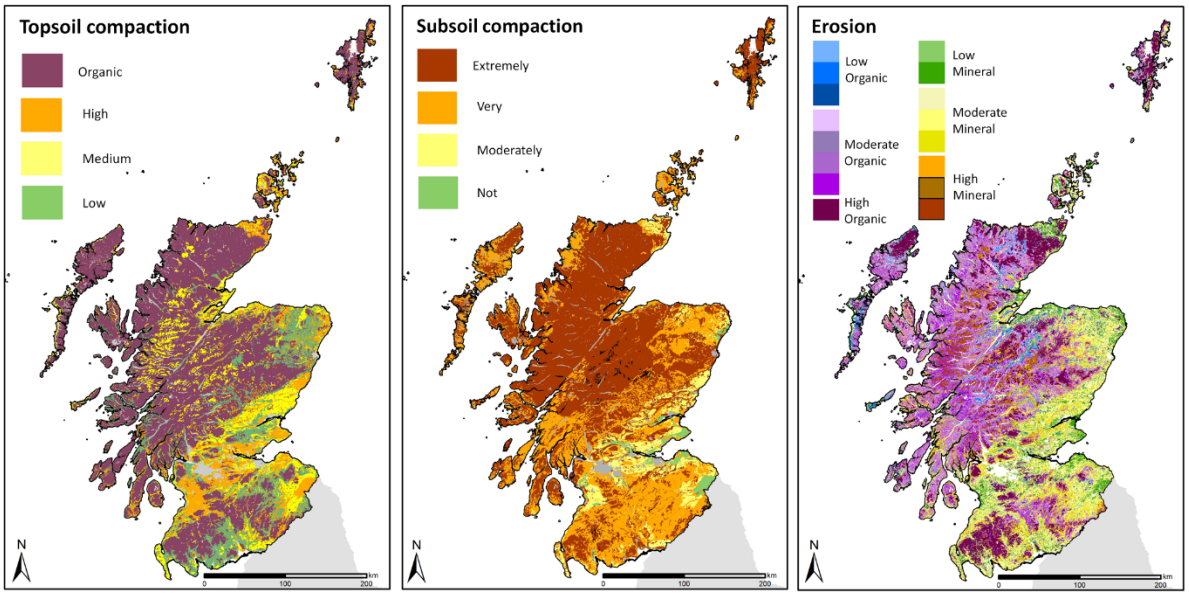


Figure 2. Scotland's soil vulnerability maps based on Soil maps of Scotland at a scale of 1:250 000[24].. Higher resolution digital maps based on the Partial Cover 1:25,000 soil map and descriptions of the classes can be found on Scotland's soils website

4.2 Key areas of consideration for Theme 2

In October 2025, we held a stakeholder workshop on soil physical degradation to identify potential cross-sectoral opportunities for better protection and restoration of soil across Scottish landscapes. The workshop aimed to review the current guidance available to:

(a) Understand the causes of soil physical degradation

(b) Identify soils affected by physical degradation or at risk of future degradation and

(c) Support and advice available to alleviate issues and restore soil physical health.

This generated useful evidence on the causes and impacts of physical soil degradation. The workshop outputs are shown in Appendix C.

4.2.1 Causes of physical soil degradation

The use of heavy machinery (e.g., for cultivation or in construction) was highlighted as one of the main drivers, specifically on wet soils which are more vulnerable to degradation. This was seen to be potentially exacerbated by the presence and condition of artificial drainage across agriculture, forestry and peatlands.

The removal and/or sealing of soils was a key issue in altering the response of the land to rainfall (surface water infiltration, runoff and erosivity) with impacts on flood risk as well as potentially affecting soil and land stability (creeping / landslide). Physical degradation extends to developments such as renewables and the installation of essential infrastructure, where there is perhaps less research for developing specific guidance relating to various

[24] Macaulay Institute for Soil Research, Aberdeen. DOI: 10.5281/zenodo.4646891 (Soil Survey of Scotland Staff (1981))

types of developments and soil handling conditions (see Section 2.2.3). Climate change can exacerbate the risks of physical soil degradation which may further impact Scottish landscapes.

4.2.2 Available guidance for physical soil degradation

During the stakeholder workshop participants noted that there is useful guidance relevant to agricultural soils, such as the Valuing Your Soils brochure[25] and Scottish Government's Good Agricultural and Environmental Conditions (GAECs)[26] set out standards to minimise disturbance to soils. There are GAECs that aim to protect soils from compaction and physical degradation through the timing of management, choice of machinery, and maintenance and enhancement soil organic matter levels. They also include regulatory measures to help mitigate the impacts of soil physical degradation such as the adding of buffer strips and sediment fences along water courses. In addition, the use of uncultivated land or semi natural areas for intensive agricultural purposes or forestry systems must seek an EIA screening decision.

UK Forest Standards (2023)[27] outlines sustainable forest management principles for mitigating soil degradation relevant to compaction, such as to minimise compaction and damage to soil structure during forest operations, choosing appropriate machinery, considering the timing of operations, using brash mats to protect the soil from heavy loads and remediation options if compaction occurs that restricts tree growth.

Forest Research provide considerations for soil compaction as it is a common problem at many brownfields and contaminated sites due to activities relating to the removal, storage and reinstatement of soil materials during mineral extraction or mining activities where the ground has been subjected to heavy machinery traffic[28]. To minimise the risk of soil compaction during construction, particularly from heavy machinery, best practice guidance is provided, for example through Defra's code of practice[3] and the Institute of Quarrying soil guidance[29] (described in Appendix B9).

Better integration of guidance and technical support was identified as a key factor for better protecting the physical condition of Scotland's soils. This includes the integration of wider soils guidance into peatland, forestry and water policies and the need for better practical tools across land covers to help with decision making.

Appendix C2 provides a summary of the key recommendations generated from the workshop and indicates available guidance that can provide support. It notes whether the guidance is specific to a particular land use (agriculture, forestry, peat or planning sectors) and where there are potential for expanding guidance across different sectors. Knowledge

[25] Guidance is available - https://www.farmingandwaterscotland.org/soil-nutrients/valuing-your-soils/ (Accessed May 2026)

[26] https://www.ruralpayments.org/topics/inspections/all-inspections/cross-compliance/detailed-guidance/good-agricultural-and-environmental-conditions/good-agricultural-and-environmental-conditions.pdf (Accessed May 2026)

[27] https://assets.publishing.service.gov.uk/media/651670336a423b0014f4c5c0/Revised_UK_Forestry_Standard_-_effective_October_2024.pdf (Accessed May 2026)

[28] https://www.forestresearch.gov.uk/tools-and-resources/fthr/urban-regeneration-and-greenspace-partnership/practical-considerations-and-challenges-to-greenspace/soil-compaction-practical-considerations/ (Accessed May 2026)

[29] https://www.quarrying.org/soils-guidance (Accessed May 2026)

sharing through cross-sector networks and peer to peer learning provides beneficial pathways to identifying and alleviating soil physical issues, as well as exploring opportunities to financially support the adoption of best practice in the field (e.g., public and private sector initiatives).

4.3 Options for action for Theme 2

T2-O1: Develop cross-sector guidance on soil compaction and soil physical degradation:

Produce cross-sectoral guidance on preventing, identifying and alleviating soil compaction for a range of management scenarios including case studies across sectors (agriculture, forestry, peatlands and planning). These should include details on the links between soil compaction and risk of soil erosion, providing, information on available guidance and regulatory measures associated with mitigating its impacts.

T2-O2: Explore opportunities for soil compaction to be identified and alleviated through existing programmes:

For example, explore opportunities to include measures for soil compaction tests while also including a record of erosion occurrence within the Whole Farm Plan soil tests (see Section 4.1.2.1)

T2-O3: Update guidance and tools informing the risk of Scottish soils to physical degradation and compaction:

Scotland's soils website[30] provides national (partial cover) maps showing soil vulnerability (risk) to degradation. There are opportunities to develop these further with additional and broader evidence and improve guidance for use at more local scales. For example, a national field-based assessment of the extent of both topsoil and subsoil compaction (similar to recommendations in the draft EU Soil Monitoring and Resilience Directive[31]) to provide improved understanding of the relationships between land management intensity, erosion, runoff and compaction.

This will support continued understanding of these issues and appropriate decision making for improved soil protection. There could also be the development of materials produced for the agricultural sector such as the 'Valuing your Soils'[25] brochure.

[30] https://soils.environment.gov.scot/maps/risk-maps/ (Accessed May 2026)

[31] Directive (EU) 2025/2360 of the European Parliament and of the Council of 12 November 2025 on soil monitoring and resilience (Soil Monitoring Law) https://eur-lex.europa.eu/eli/dir/2025/2360/oj (Accessed May 2026)

5 Chemical and biological soil health (Theme 3)

5.1 Background

Soil chemistry plays a vital role in soil fertility in terms of soil nutrient content, retention (solubility and leaching risk) and availability to crops/plants. The chemical composition of soils is governed by dynamic interactions between inherent soil properties (e.g. soil organic matter content, inorganic mineral composition, clay content, water holding capacity, pH and biological activity etc), soil structure (controlling in part the availability of water, oxygen and nutrient), land use (both present day and historical land management) and the acute and/or chronic exposure to chemical hazards.

The application of soil fertilisers and amendments are widely conducted in modern agriculture to enhance productivity. However, poor soil nutrient management and the introduction of chemicals in managed systems (e.g., nitrogen management in forestry / farming systems) can lead to issues such as soil acidification, detrimental impacts on nearby habitats (particularly sensitive habitats like peatlands) and potentially the eutrophication of local watercourses. In urban and industrial areas, the accumulation of hazardous heavy metals like lead and cadmium can occur, posing further risks to soil and water quality. Degradation of soils in this way can negatively impact soil microbial communities and beneficial organisms, which can further exacerbate degradation of soils and lead to a decline of soil functions. There is also new awareness of emerging contaminants such as pesticides, microplastics and per- and polyfluoroalkyl substances (PFAS) being introduced to soils through the application of soil amendments (e.g., sewage sludge, rock dust and biochar) and the long-term impacts in terms of their persistence, accumulation and subsequent impact on soil health and functioning over time. Potential subject areas for a Theme 3 task group to consider are;

5.1.1 Soil contamination

5.1.1.1 Contaminated land

Soil contamination is primarily a consequence of industrial processes in the past but also arises from other processes such as air pollution and atmospheric deposition (ESS report 2024[32]). SEPA[33] recognises that historic land contamination arose from a lack of knowledge about potential environmental hazards and poor practices being conducted in the past (for example previous industrial processes, disposal of waste by landfilling and illegal tipping, and leaks and spills of raw materials, process effluents and fuels). It is difficult to accurately judge the total number of affected sites in Scotland as individual local authorities have chosen a variety of assessment methods, but a 2009 SEPA report[34] demonstrated the extent of contaminated and potentially contaminated land in Scotland.

[32] The risks to Scotland's soils: a scoping report - Environmental Standards Scotland (Accessed May 2026)
[33] Contaminated land | Scottish Environment Protection Agency (SEPA) (Accessed May 2026)
[34] Dealing with Land Contamination in Scotland: A review of progress 2000 - 2008 (Accessed May 2026)

The contaminated land regime (Part IIA of the Environmental Protection Act 1990[35]) is designed to address the legacy of historic contamination through local authorities, who are responsible for the identification of contaminated land in their respective areas. In terms of soil remediation, the regime is designed on the 'polluter pays' principle. However local authorities have powers to carry out remediation work where polluters/owners cannot be traced, cannot pay for remediation for reasons of hardship, or where the local authority owns the land (Environmental Protection Act 1990[35]). A recent scoping report[32], by Environmental Standards Scotland suggested that local authorities are not utilising powers under Part IIA routinely. Industrial activities are regulated under the Environmental Authorisation (Scotland) Regulations 2018 (EASR)[36] [superseding Pollution Prevention Control and Controlled Activities Regulations amongst others] and the Environmental Liability Regulations, which offers support for limiting the risk of future soil contamination.

5.1.2 Nutrient Management and Diffuse Pollution

5.1.2.1 Nutrient Management in Agriculture

It is acknowledged that the addition of fertilisers is an important agricultural practice for the improvement of growing condition and overall agricultural productivity. However, poor nutrient management can lead to the leaching and runoff of nutrients into groundwater and watercourses reducing water quality (and contributing to indirect GHG emissions). Defra Agri-climate report 2024[37], estimated that agriculture was responsible for 70% of total nitrous oxide emissions in 2022 with the majority of agricultural nitrous oxide emissions coming from soils, particularly as a result of nitrogen fertiliser application, manure and leaching/run off. Buckingham et al (2023)[38] showed that the reduction of synthetic nitrogen fertiliser uses and/or the optimisation of nitrogen application (including the use of legumes and cover crops to offset the dependence on synthetic N use) was listed as a top priority for GHG and ammonia emissions mitigation.

Scotland's Climate Change Plan: 2026–2040 Annex 2 – Sectoral Annexes[23] outlines that Scottish Government will support Scottish farmers and crofters to reduce GHG emissions while maintaining and/or improving their soil for agricultural productivity. Scottish Government produced the Action Programme for Nitrate Vulnerable Zones (Scotland) Regulations 2008[39] (as amended), to meet Scotland's legal and environmental obligations for NVZs which set out requirements for from farmers to comply with the NVZ rules such as nitrogen application limits, compliant manure storage, manure spreading restrictions and buffer zones where no applications are permitted.

In Scotland, registration authorisation is required through SEPA EASR authorisations[40] for the use of waste on land for the purposes of soil improvement including the use of sewage

[35] Environmental Protection Act 1990 - Part IIA Contaminated Land: statutory guidance edition 2 - gov.scot (Accessed May 2026)
[36] The Environmental Authorisations (Scotland) Regulations (EASR) 2018 https://www.legislation.gov.uk/ssi/2018/219/contents/made (Accessed May 2026)
[37] Agri-climate report 2024 - GOV.UK (Accessed 2026)
[38] https://journal.hep.com.cn/fase/EN/10.15302/J-FASE-2023495 (Accessed May 2026)
[39] https://www.legislation.gov.uk/ssi/2008/298/contents/made (Accessed May 2026)
[40] https://beta.sepa.scot/regulation/authorisations-and-compliance/easr-authorisations/waste-activities/soil-improvement-using-waste/ (Accessed May 2026)

sludge on agricultural land (discussed further in Section 4.1.2.2). The good practice guidance Good Agricultural and Environmental Conditions[26] (GAEC) is also relevant here, notably, (GAEC 1) to protect against pollution through the restricting the storage, application of fertilisers and pesticides and cultivations along watercourses. Other GAECs will also contribute to reduced nutrient leaching and diffuse pollution through reducing soil erosion risks including maintenance of soil organic matter and the minimising of time with minimum soil cover. Scotland's Climate Change Plan: 2026–2040 Annex 2 – Sectoral Annexes[23] highlights research and development have identified new, innovative ways to reduce nitrogen emissions from soil and our findings will have been translated to practical, real-world solutions.

In addition, 2028 farmers and crofters will also be asked to produce a nutrient management plan (NMP) to complement their soil analysis as part of the Whole Farm Plan (WFP)[41] although this is not yet compulsory. Scottish Government currently recommends NMP are prepared using PLANET (Planning Land Applications of Nutrients for Efficiency and the Environment[42]) or programmes which allow you to produce a nutrient management plan are also acceptable as long as they are relevant to Scottish conditions and fertiliser recommendations. It also highlights fertiliser recommendations (i.e., based on relevant SRUC technical notes) to reduce excess soil nutrients which may be leached or mineralised (leading to direct and indirect GHG emissions).

Whole Farm Plan[41] guidance also highlights that many other factors can also affect the uptake of nutrients for growing crops including soil compaction and poor soil structure limiting root growth and therefore uptake of nutrients (The Visual Evaluation of Soil Structure - VESS[43] guide can be used to measure soil structure). This is also supported in The Code of Practice on Sustainable and Regenerative Agriculture[44] as part of the Agricultural Reform Programme and associated list of regenerative measures outlined in their Vision for Agriculture[45] (which the WFP sits within), which focuses on nature restoration, climate mitigation (reducing greenhouse gases/carbon sequestration), and high-quality food production.

5.1.2.2 Soil amendments

Soil amendments are materials added to soil to improve soil health or functioning (e.g., aeration, pH and nutrient levels). As an important component of Scotland's ambitions to reduce wastes and improve circularity, there is growing interest in the application of certain materials and wastes to land to improve soil nutrient status. However, there is the potential for exposing soils to known and emerging contaminants (Section 4.1) and so the application of waste to land is regulated by SEPA[46] (Section 4.1.2.1), with the overarching aim being to

[41] https://www.ruralpayments.org/topics/all-schemes/whole-farm-plan/ (Accessed May 2026)

[42] https://www.planet4farmers.co.uk/Content.aspx?name=PLANET (Accessed May 2026)

[43] https://www.sruc.ac.uk/media/xbrfn4x3/vess-colour-chart.pdf (Accessed May 2026)

[44] https://www.gov.scot/publications/code-practice-sustainable-regenerative-agriculture-2/ (May 2026)

[45] https://www.gov.scot/publications/next-step-delivering-vision-scotland-leader-sustainable-regenerative-farming/ (Accessed May 2026)

[46] https://beta.sepa.scot/regulation/authorisations-and-compliance/easr-authorisations/waste-activities/soil-improvement-using-waste/use-of-waste-on-a-single-site-for-soil-improvement/ (Accessed May 2026)

ensure materials provide genuine agricultural or ecological benefit without causing pollution.

Biochar is a carbon rich material often derived from the pyrolysis of organic waste. It has attracted significant attention in recent years, particularly in terms of potential to sequester carbon in soils over long periods and ongoing research into its potential to improve soil fertility, but significant evidence gaps remain regarding the efficacy of biochar under Scottish conditions. There is also a lack of data outlining the cost-effectiveness, supply chain logistics, and farmer perceptions in the Scottish context. ClimateXChange is currently researching the evidence for how biochar performs (e.g., in relation to organic-rich soils and high-rainfall environments typical to Scotland), its potential interactions with existing land management practices and uncertainties around the lifecycle emissions (publication on the ClimateXChange website is expected summer 2026).

The application of rock dust, or enhanced rock weathering (ERW) to soils has gained commercial attention due it's potential for creating a pathway for enhanced long-term carbon storage. ERW[47] comprises volcanic material being added to soils. In Scotland, the rock material is usually considered a by-product of activities such as quarrying (not classified as a waste) and so there are no regulations regarding its application to soil at present.

The Environment Agency (2025)[48] highlight several issues, including potential risks to soil health. A Scottish Government Advisory note[49] (August 2024) discussed soil-based carbon storage activities and highlighted enhanced rock weathering as being less well-evidenced in terms of potential outcomes on the broader environment and that potential impacts water quality and biodiversity in catchments and near shore needs investigation.

5.1.2.3 Nutrient management in forestry

Version 5 of the UK Forestry Standard (UKFS) (2025)[50] provides the technical standard for forestry in Scotland and sets out the legal and good practice requirements to be followed. Section 8 of the UKFS (2025) refers directly to soils offering guidance on best forestry practice to protect soils and limit nutrient losses. To mitigate the risks of potential nutrient loss arising from soil disturbance and erosion caused by forestry practices, guidance (Table 5) is provided by Scottish Forestry and UKFS.

[47] https://www.fas.scot/article/what-is-rock-dust-enhanced-weathering-and-how-it-can-affect-soil-health-and-carbon-sequestration/ (Accessed May 2026)

[48] https://assets.publishing.service.gov.uk/media/68bec4c8c771153e08e0dd19/Enhanced_rock_weathering_-_evidence_on_potential_environmental_impacts_and_social_implications.pdf (Accessed May 2026)

[49] https://www.gov.scot/publications/academic-advisory-panel-soil-carbon-and-natural-capital-markets-advisory-note/ (Accessed May 2026)

[50] The UK Forestry Standard (UKFS) | Scottish Forestry (Accessed May 2026)

Table 4. UKFS[48] recommendations to reduce soil disturbance, erosion and nutrient loss.

UKFS	Description
10	Base forest management decisions on an informed knowledge of its soil types.
11	Consider the potential impacts of soil disturbance when planning operations involving cultivation, harvesting, drainage and road construction; minimise the soil disturbance necessary to secure management objectives and amend practices to manage the risks posed.
12	Avoid removing stumps unless for tree health reasons or the purposes of restoration, or where a risk-based assessment has shown that adverse impacts on soil carbon can be mitigated.
13	Consider woodland creation to protect erosion-prone soils, stabilise slopes and intercept sediment run-off from upslope.
14	Address the risks of soil erosion as part of the forest and operational planning processes, ensuring mitigation measures are implemented when the soil will be exposed.
15	on steep slopes where there is a risk of slope failure or serious erosion, use native species and low impact silvicultural systems including continuous cover forestry where possible.
18	Minimise the use of fertilisers and confine these to areas where analysis clearly shows management benefits; if they will be used, plan applications to minimise the risk of nutrient loss.

5.1.3 Forever Chemicals and Contaminants of Increasing Concern

Forever chemicals, or PFAS (per- and poly-fluoroalkyl substances), comprise a group of thousands of chemicals that are persistent in our environment through accumulation in soils, plants and animals. The UK Government (on behalf of all devolved governments) has recently published 'PFAS Plan: building a safer future together'[51] (February 2026) to address this issue by:

(1) understanding PFAS sources
(2) tackling PFAS pathways, including reducing PFAS at source and preventing PFAS from entering and circulating in the environment
(3) reducing ongoing exposure to PFAS.

Action 1.3 of the plan relates specifically to soils, aiming to improve monitoring of PFAS in soils by supporting the British Geological Survey's feasibility study and initiating pilot sampling. The plan also outlines the need to review the risks of PFAS in sewage sludge being spread to land.

Contaminants of Increasing Concern (CICs) comprise chemical groups such as pharmaceuticals and pesticides, biological contaminants such as pathogens and

[51] https://www.gov.uk/government/publications/pfas-plan/pfas-plan-building-a-safer-future-together (Accessed May 2026)

antimicrobial-resistant (AMR) genes, nanomaterials, and microplastics. A comprehensive report by CREW (2024)[52] (Helwig et al., 2024) highlighted that no emerging contaminant groups can be discounted for Scotland and that many national and international databases are available to aid understanding of emerging contaminants, which should be reviewed and consolidated for Scotland. The report also recommends that new partnerships are considered for certain contaminant groups to refine the knowledge gaps, that funding is made available to address these and that international policy options are reviewed for integrated approaches and approaches to mixtures, including effect-based monitoring.

Fidra (2024)[53] reported that a build-up of persistent contaminants from agricultural activities (e.g., PFAS, microplastics, and pseudo-persistent contaminants such as bisphenols) has resulted in a 'cocktail' effect of contaminants within the soil causing detrimental impacts on these essential functions. In addition, the report highlights that the accumulation of these contaminants is expected to continue with the full effects on soils' ecosystem services currently unknown, prompting the recommendation for a precautionary approach.

5.2 Options for action for Theme 3

T3-O1. Support the identification and remediation of contaminated land:

Review opportunities to improve the identification of contaminated soils and mechanisms that would support appropriate remediation.

T3-O2. Review and further develop guidance to support nutrient management planning in agriculture:

Incentivise the adoption of nutrient management planning within the Whole Farm Plan, providing training and guidance where needed.

T3-O3. Develop research and guidance on the application or soil amendments for nutrient management:

As we strive to improve circularity and recycle wastes, there is the need for research to fully understand the long-term implications of novel amendments on the health of Scottish soils and wider environmental impacts.

T3-O4. Monitor progress of the Whole Farm Plan:

Explore the potential to collate data generated from the Whole Farm Plan scheme (e.g., soil analysis and nutrient management planning) to feed back into research, soil monitoring, soil model calibration and validation as well as contributing to more widely to future decision-making processes

52 https://www.crew.ac.uk/sites/www.crew.ac.uk/files/publication/CRW2022_06_Emerging%20contaminants%20report%20and%20appendices_0.pdf (Accessed May 2026)

53 https://fidra.org.uk/download/soil-health/ (Accessed May 2026)

T3-O5. Advance research on forever chemicals and emerging contaminants in Scottish soils:

Support research into the risks of emerging contaminants, particularly with respect to identifying and prioritising new contaminants, limiting routes to exposure, benchmarks relating to soil health, opportunities for circularity and assessing the long-term risks to soil and human health.

6 Soils in the private sector (Theme 4)

6.1 Background

All businesses rely on nature in some way and are therefore susceptible to nature-based risks which can lead to significant operational and supply chain disruptions. Potential risks to soil stability, resilience and soil health can lead to cascading environmental and socio-economic impacts. Examples of nature-based risks to businesses include:

- water scarcity (e.g., from overuse or over extraction of water sources)
- extreme weather (droughts, flooding, storm damage)
- natural disasters (e.g., landslides)
- invasive species (pests and diseases)
- soil degradation or erosion (affecting crop and timber production, catchment water management and water quality etc).

"Making the Case for Nature" (2025)[54] highlights that Scotland's economy is highly reliant on natural capital and the need to maintain natural capital assets in good condition to ensure sustainable economic growth. The report also highlights that both public funding and private finance will be essential to ensure sufficient investment to meet nature restoration goals. The Natural Capital Market Framework (2024)[55] outlines that enhancing our natural capital is a public and private responsibility with the Scottish Government already investing significantly into the creation of woodlands, the restoration of peatlands, and the protection of biodiversity.

In February 2025 Scottish Government published the Invest in Nature[56] plan outlining their plan of action to support the creation of a nature finance system that enables funding and finance to flow into high integrity biodiversity outcomes. This highlights the ambition to improve market mechanisms that align with broader market trends, such as the Taskforce on Nature-related Financial Disclosures (TNFD) as UK companies increasingly integrate nature-based solutions into their financial disclosures, transition planning, and supply chain management.

The Scottish Government is funding research into 'Understanding the value of Scotland's agricultural soil natural capital[57]' as part of Scottish Government's Environment, natural

[54] Introduction - Making the Case for Nature: insights from Scotland's Natural Capital analyses - gov.scot (Accessed May 2026)
[55] Market Framework for Natural Capital (Accessed May 2026)
[56] Biodiversity Investment Plan (Accessed May 2026)
[57] Understanding the value of Scotland's agricultural soil natural capital | SEFARI (Accessed May 2026)

resources and agriculture - strategic research 2022-2027[58], which aims to identify the underpinning natural capital assets for key ecosystem services produced by agricultural soils, the appropriate biophysical metrics, and indicators to measure the extent and condition of agricultural soils and determine and apply the appropriate valuation methods to agricultural soils.

6.2 Key areas of consideration for Theme 4

6.2.1 Soils in carbon management frameworks

The Scottish Government has proposed a legally binding target of net-zero emissions by 2045. UK territorial GHG emissions are reported annually (by the Department for Energy Security and Net Zero) in line with Intergovernmental Panel on Climate Change (IPCC) reporting requirements[59] across key sectors[60] to track progress towards international and domestic GHG emissions reduction targets. Soils are a core component of global carbon cycling (Appendix D1) contributing to both carbon emissions, reductions and removals. For example, nitrogen emissions are also considered in terms of soil nutrient management (see Section 4.1.2).

Carbon management forms an integral part of a company's ESG (environmental social and governance) reporting through climate-related frameworks such as International Financial Reporting Standards (IFRS) S2 Climate-related Disclosures[61]. The ISSB and IFRS Standards[62] offer a global framework to understand and disclose material climate risks through reporting on governance, strategy, risk management, and metrics utilised in the assessments. Environmental Reporting Guidelines[63] are also available to help companies understand how to meet climate-related financial disclosure requirements.

The GHG Protocol Corporate Accounting and Reporting Standard[64] provides requirements and guidance for companies and other organisations preparing a corporate-level GHG emissions inventory, which aligns to IPCC reporting requirements[59] Guidance on how to estimate scope 3 emission reductions are provided in the GHG Protocol's Corporate Value Chain (Scope 3) Standard[65] and more specific to land-based carbon management guidance is provided in the Land Sector and Removals Standard[66] (released January 2026). The Land Sector and Removals Standard[66] can be used by companies to better understand the GHG emissions and removal impacts of land management, land use change, biogenic products and other CO_2 removal activities across their supply and value chains. It can provide the baseline from which to set emission reduction targets and performance to

[58] Strategic Research Programme 2022 to 2027 - Environment, natural resources and agriculture - strategic research 2022-2027: overview - gov.scot (Accessed May 2026)
[59] Publications - IPCC-TFI (Accessed May 2026)
[60] Electricity supply, fuel supply, domestic transport, buildings and product uses, industry, agriculture, waste, and emissions/removals from Land Use, Land-Use Change and Forestry (LULUCF).
[61] https://www.ifrs.org/issued-standards/ifrs-sustainability-standards-navigator/ifrs-s2-climate-related-disclosures/ (Accessed Amy 2026)
[62] IFRS - Introduction to the ISSB and IFRS Sustainability Disclosure Standards (Accessed May 2026)
[63] Environmental Reporting Guidelines (Accessed May 2026)
[64] Corporate Standard | GHG Protocol (Accessed May 2026)
[65] Corporate Value Chain (Scope 3) Standard | GHG Protocol (Accessed May 2026)
[66] Land Sector and Removals Standard | GHG Protocol (Accessed May 2026)

be tracked and report progress toward GHG mitigation goals. The Science Based Targets Initiative[67] provides resources specific to Forest, Land and Agriculture (FLAG)[68] for reducing land-based emissions and enhancing carbon removals in line with science and climate targets.

6.2.2 The role of soils in nature-based solutions

A recent report by Cole et al (2026)[69] highlighted the effectiveness of applying a natural capital approach to identifying and prioritising investments for nature-based solutions (NbS) within Scottish catchments. Aligning the interests of beneficiaries with the delivery of ecosystem services can promote the implementation of sustainable soil management as part of NbS. These can promote operational resilience within a business which can lead to new innovative investments to protect natural assets, provide nature-based mitigation strategies and perhaps lower the insurance burden.

A COSLA briefing note (2020)[70] highlighted that local authorities are taking steps to support nature-based solutions (NbS) as part of their response to climate change, promote wellbeing and protect biodiversity. To date, investments for nature-based solutions (NbS) are largely publicly funded but efforts can be amplified with private investments. The COSLA briefing describes how NbS can help both climate change mitigation and adaptation through improved carbon storage and reducing carbon emissions, preventing the loss of biodiversity and protecting our natural capital. It also highlights the role of NbS in supporting a green recovery and a just transition to a net-zero economy (Figure 3).

Soils play a central role in NbS through:

- Peatland restoration to conserve and enhance carbon stores (a priority to reduce emissions and restore biodiversity in Scotland)
- Agricultural soil health to protect soil organic matter and improve water retention
- Tree planting to improve soil structure, stability (reduce erosion) and carbon sequestration
- Green infrastructure (e.g., rain gardens, green roofs, bioswales, permeable pavements, urban trees, and wetlands) to support improved air quality, water management, urban heating as well as supporting green spaces important for our general wellbeing
- Protection and enhancing capacity of blue carbon in terms of coastal soils, saltmarshes and sediments.

A 2020 report by Scottish Environment Link[71] demonstrates how land can be managed with nature in mind through nature networks[72], nature friendly farming (e.g. Nature Friendly

[67] Ambitious corporate climate action - Science Based Targets Initiative (Accessed May 2026)
[68] Forests, Land and Agriculture - Science Based Targets Initiative (Accessed May 2026)
[69] Natural Capital and River Basin Management Planning - Protecting and Improving Scotland's Water Environment | CREW | Scotland's Centre of Expertise for Waters (Accessed May 2026)

[70] https://www.cosla.gov.uk/__data/assets/pdf_file/0025/26656/EM-Briefing-Nature-Based-Solutions.pdf (Accessed May 2026)
[71] NbS-LINK-briefing-FINAL-8.pdf (Accessed May 2026)
[72] Nature Networks Framework | NatureScot (Accessed May 2026)

Farming Network[73]). It recommends a range of actions such as terminating peat extraction, improving peat restoration, creating native woodlands and protecting ancient woodlands as well as provisioning new agri-environment schemes that support and incentivise land managers to maintain, restore and create species-rich grasslands at scale.

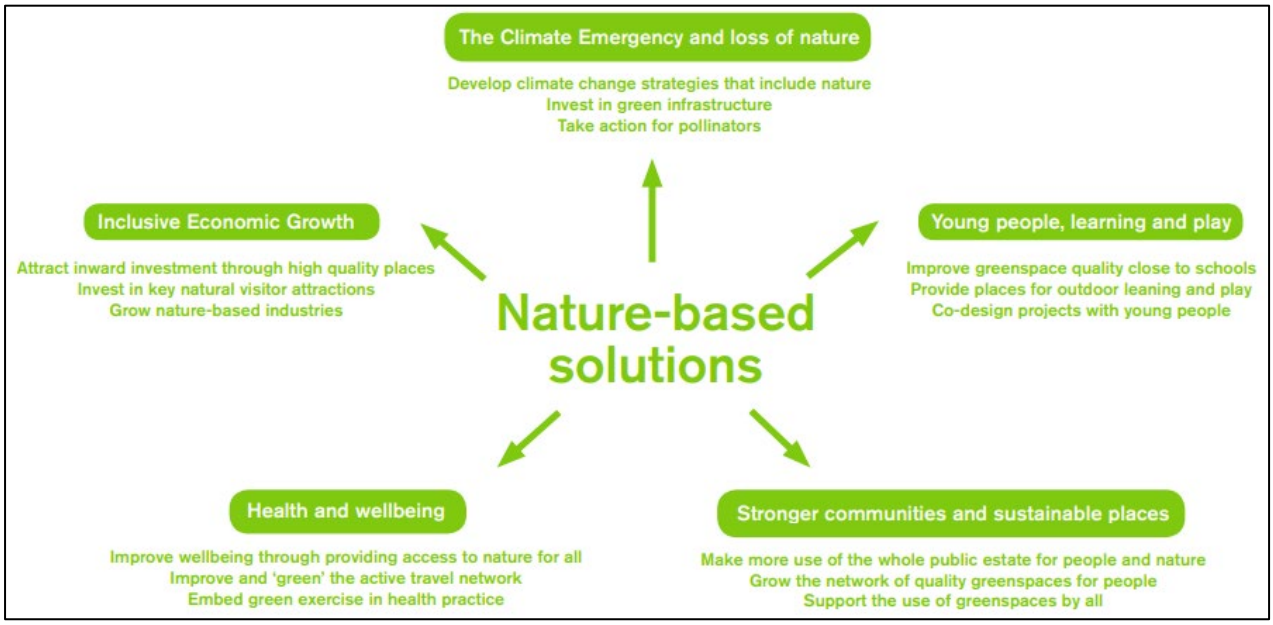


Figure 3. The role of Nature Based Solutions in Scotland

6.2.3 Soils in Nature-Related Financial Disclosures frameworks

The Taskforce for Nature-Related Financial Disclosures (TNFD)[74] is an international framework that provides a mechanism for business and financial institutions to assess, report and act on their nature-related dependencies, impacts, risks and opportunities. The standardised approach allows companies to integrate nature into their business strategy and decision making. The TNFD framework comprises a set of disclosure recommendations and sector-specific guidance that is consistent with carbon management reporting (e.g., ISSB Standards[61]). This involves 4 core pillars of disclosures including:

(1) Governance of nature-related dependencies, impacts, risks and opportunities
(2) Strategy and financial planning to manage nature-related dependencies, impacts, risks and opportunities in the organisation's business model
(3) Risk and impact management processes used by the organisation to identify, assess, prioritise and monitor nature-related dependencies, impacts, risk and opportunities
(4) Metrics and targets used to assess and manage material nature-related dependencies, impacts, risks and opportunities.

Scottish Government's ambition through the Invest in Nature plan is to support investment into Scottish biodiversity and climate adaptation, to improve market mechanisms by

[73] https://www.nffn.org.uk/ (Accessed May 2026)
[74] The Taskforce on Nature-related Financial Disclosures (Accessed May 2026)

aligning with broader market trends with growing influence, such as TNFD. As UK companies increasingly integrate nature-based solutions into their financial disclosure, transition planning, and supply chain management, the demand for voluntary biodiversity and nature markets is expected to rise. An Ecosystem Restoration Code[75] (an outcome of Scotland's Natural Capital Market Framework[76] and Principles for Responsible Investment in Natural Capital[77]) strengthens Scotland's position in ensuring responsible private investment to support sustainable and high-integrity ecosystem restoration projects.

A review of TNFD's sector specific guidance shows all sectors have a dependency on soil and sediment retention or soil quality regulation (Table 5) with 12 of the 15 sectors having 'Very High' dependency on soil and sediment retention or soil quality regulation (see Appendix D2 and D3 for specific activities these dependencies relate to). However, despite soil's intrinsic link to ecosystem services, the TNFD 2025 Progress Report[78] showed that only 16% of companies surveyed noted soil degradation as a priority area for corporate engagement. The report highlights 'pollutants' released to soil as a key indicator, but only 10% felt this was a very feasible metric to report and 36% saying it was not feasible as all (Appendix D4). This highlights that there are opportunities to support further knowledge, guidance and monitoring of soils within corporate reporting.

Draft sector guidance for Technology and Communications[79] and Alternative Fuels[80] has been issued for consultation. Both refer to soils as important natural capital assets to consider within nature-related financial risk assessments. For example, in relation to technology and communication, soils are considered in connection to the impacts on soils from mining for materials, development of data centres and in terms of managing contamination from wastes. For alternative fuels, the guidance explores evaluating possible benefits and impact on soil health from biofuel and bioenergy production. Although not all of these sectors will be pertinent to the health and vulnerability of Scottish soils, Table 6 shows how soils underpin our natural resources and feed into economic stability.

Table 5. Soil-specific ecosystem services that each sector typically depends on as outlined within TNFD sector-specific guidance[81]

Sector	Dependency on soil & sediment retention or soil quality regulation
Beverages	Very High – Low
Metals and mining	Medium
Marine transportation and cruise lines	Medium – Low
Apparel, accessories and footwear	Very High – Low
Aquaculture	Very High – Low

[75] Supporting documents - Ecosystem Restoration Code (ERC): A Competent Model for private investment in nature restoration in Scotland - gov.scot (Accessed May 2026)
[76] Natural Capital Market Framework - gov.scot (Accessed May 2026)
[77] Principles for Responsible Investment in Natural Capital - gov.scot (Accessed May 2026)
[78] 250918_TNFD-Status-Report_DIGITAL.pdf (Accessed May 2026)
[79] Draft sector guidance - Technology and communications – TNFD (Accessed May 2026)
[80] Draft sector guidance – Alternative fuels – TNFD (Accessed May 2026)
[81] https://tnfd.global/tnfd-publications/?_sft_framework-categories=additional-guidance-by-sector (Accessed May 226)

Sector	Dependency on soil & sediment retention or soil quality regulation
Biotechnology and pharmaceuticals	Very High - Very Low
Chemicals	Very High - Very Low
Construction materials	High – Low
Electric utilities and power generators	High - Very Low
Engineering, construction and real estate	High - Very Low
Fishing	Very High – Low
Food and agriculture	Very High – Low
Forestry and paper	Very High – Low
Oil and gas	Medium – Low
Water utilities and services	High - Very Low

6.2.4 Soils in nature-based financial markets

The Peatland Code[82] and Woodland Carbon Code[83] are established UK voluntary carbon standards. The Peatland Code launched in 2015 by the IUCN UK Peatland Programme supports peatland restoration by facilitating private investments. Similarly, the Woodland Carbon Code provides a framework for landowners to verify and sell carbon credits created through woodland creation and its associated carbon sequestration. Making the Case for Nature[54] report showed that the investment in carbon credits generated by woodland creation and peatland restoration has been significantly focused on Scotland, accounting for 81% of UK Woodland Carbon Code projects and 87% of Peatland Code projects. A 2023 Scottish Government report[84] assessing private finance in natural capital highlighted that public investment in peatland restoration has increased in recent years but remains below what is needed to restore this natural asset at scale alongside some investment from private sources[84].

In terms of soils in agricultural land use, Black et al (2022)[85] conducted a global review of farmland soil carbon codes and explored the potential for an overarching standard for soil carbon codes to be used in the UK against which existing codes (and other schemes already generating soil carbon credits) could be assessed and benchmarked.

There are many parameters influencing organic matter input, decomposition and carbon losses to a soil system (for example geochemical properties; soil physical, chemical and biological characteristics, local climate, topography, current and historic land use including the range of management practices applied). The dynamic and heterogeneous nature of soils means it is difficult to accurately quantify sequestered soil organic carbon stocks spatially. There are also challenges in identifying new (additional) carbon storage generated

[82] Peatland Code | IUCN UK Peatland Programme (Accessed May 2026)
[83] The Woodland Carbon Code | Woodland Carbon Code (Accessed May 2026)
[84] Executive summary - Mobilising private investment in natural capital: report - gov.scot (Accessed May 2026)
[85] Full article: What makes an operational farm soil carbon code? (Accessed May 2026)

as a direct result of a given management practice and in being able verify the permanence of the additional carbon stocks over time.

In this context it is important to consider soils in terms of net balance of carbon - it is not just about adding more carbon, but also mitigating against carbon losses (directly as CO_2 emission or indirect emissions from leached soil carbon). A core component is evidencing soil carbon stock baselines from which changes can be monitored.

6.3 Options for action for Theme 4

T4-O1. Continued support for peatland restoration and woodland creation:

The benefits of peatland restoration and woodland creation in mitigating the impacts of climate change and nature recovery are well documented. Voluntary carbon schemes offer a valuable mechanism for private investments to support policy objectives, but we need to improve our understanding of the carbon cycling in soils in woodlands and their overall GHG mitigation potential.

T4-O2. Review policies for aligning a soil monitoring framework with environmental sustainability reporting standards:

There are opportunities to explore how a Scottish Soil Monitoring Framework (Section6, Theme 5) could better align and contribute to technical standards (e.g. GHG Protocol) that feed into UK Sustainability Reporting Standards[86] and Sustainability Disclosure Requirements[87]. For example, the EU Soil Monitoring Law provides a legal framework that supports the collection of quantitative soil data that feeds directly into several European Sustainability Reporting Standards (ESRS). This makes soil monitoring a key component of ESG compliance for sectors such as agriculture, construction and manufacturing that rely on soil resources. Activities within the Land Use for Net Zero Hub could offer opportunities to explore this further and identify mechanisms for alignment where soil monitoring (e.g. Loades et al., 2026[88]) can inform transition plans towards improved sustainability and net zero (e.g. LUNZ projects[89]).

T4-O3. Review policies for aligning a soil monitoring framework with nature-based frameworks:

There are opportunities to consider Scottish soils more through the lens of natural capital reporting to support further implementation of nature-based solutions and the delivery of climate-risk mitigation. For example, by exploring the linkages between soil health assessments with dynamic ecosystem services to inform decision making and support the adoption of nature-based solutions.

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[86] https://www.gov.uk/guidance/uk-sustainability-reporting-standards (Accessed May 2026)

[87] https://www.fca.org.uk/firms/climate-change-and-sustainable-finance/sustainability-disclosure-requirements-sdr-regime (Accessed May 2026)

[88] https://lunzhub.com/wp/wp-content/uploads/2026/04/LUNZ-Hub-Calldown-15-Aligning-soil-monitoring-methods-and-metrics-across-the-4-Nations.pdf (Accessed May 2026)

[89] Projects - LUNZ Hub (Accessed May 2026)

T4-O4. Develop guidance on appropriate use and limitations of soil metrics in corporate reporting and verification:

Consider how Scottish Government funded research might support the use of appropriate, robust data in the verification of soil carbon stock changes (and terrestrial GHG emissions).

T4-O5. Review the guidance and incentivise further mobilisation of soil protection, restoration and enhancement through the adoption of financial frameworks:

Initiatives such as the TNFD are not legally mandatory in the UK. However, advancing the adoption of such initiatives would benefit Scottish soil resources and wider nature networks and offer a mechanism for mobilising action.

7 Soil monitoring and metrics (Theme 5)

7.1 Background

Soil monitoring is a vital component of evidence-based policy across all Scottish land covers and soil types. However, soil systems are heterogeneous and naturally change over space and time with respect to climate and biogeochemical processes, while supporting a range of ecosystem functions. Layered on top of these natural features are anthropogenic impacts on soils through land use and management practices across sectors and landscapes.

Despite these challenges, the 2025 route map[1] highlighted that Scotland already has a wealth of data and knowledge on soils. Data already gathered can provide baselines for an assessment of the magnitude and duration of changes and how these impact upon soil's contribution to wider ecosystem services.

To effectively understand these linkages, soil data and metrics is required across field, regional and national scales. Field-scale knowledge is useful for making land management decisions that directly affect local soil resource security and soil health. It feeds into regional and national knowledge important for landscape scale decision making or for forecasting and modelling scenarios for future planning.

7.2 Key areas of consideration for Theme 5

7.2.1 Supporting a soil monitoring framework for Scotland

As highlighted in Section 5, soils are integral to Scotland's natural capital and so there is potential to embed a national soil monitoring framework across policy to support the delivery of various nature-based policy objectives. The development of a framework requires a clear vision and purpose that will provide transparent knowledge on Scottish soil systems for multiple end users.

The Scottish Soil Framework (2009)[90] and Soil Route Map for Scotland Report 2025[1] outline broad objectives for soil protection, restoration and enhancement. In order to monitor soils and the various components of soil systems, establishing a baseline from which changes in soil condition can be benchmarked is a key starting point. It is also important to consider the

[90] The Scottish Soil Framework - gov.scot (Accessed May 2026)

appropriate data resolution (spatially and temporally) required to capture adequate detail to allow for robust analyses and interpretation (discussed further in Appendix E1).

Through the Strategic Research Programme 2022-2027[58]Scottish Government is investing in the optimisation of Scottish legacy soil data and working to develop an operational monitoring framework. Appendix E2 outlines the range of datasets being reviewed to inform the development of a Scottish soil monitoring framework and Appendix E3 provides a description of the National Soil Inventory of Scotland (NSIS)[91] that provides a key platform describing Scotland's soil resources. Key development components in the current programme include:

- The statistical design with which to identify change and how to build on Scottish legacy data sets such as the National Soil Inventory of Scotland (NSIS) described in Appendix E.
- The development of new statistical techniques that can be used to combine data sets and create a larger and more robust baseline against which change can be assessed.
- An assessment of measurement techniques and the availability of baseline data for new indicators such as eDNA and the quantification of emerging contaminants such as PFAS and microplastics.
- The use of novel analytical techniques (e.g., FTIR/XRD92) that could increase the value of the data measured in Scotland.
- The value of data from big data sets and commercial soil assessments and the implications for designing standard protocols so samples can be used together with data from more robust statistically designed data sets.

Recent research has explored existing datasets to identify metrics which could support the monitoring of Scotland's soil health and measure the vulnerability if Scottish soils to a changing climate[93]. The potential to align soil metrics used in soil monitoring across the four UK nations has been reviewed through a UK Land Use for Net Zero (LUNZ) funded project (Loades et al., 2026[88]). This reviewed appropriate indices for informing soil health characteristics across the home nations and whether specific indicators are already present in national data sets. It also considered where further research and data gathering may be required, including the need to test and validate more novel indicators to fully understand inherent heterogeneity and uncertainty. This would improve appropriate interpretation as part of soil-related decision making.

7.2.2 Peatland restoration monitoring in Scotland

The Scottish National Adaptation Plan[2] and Scottish Biodiversity Delivery Plan 2024-2030[94] both include a commitment to develop a national peatland restoration monitoring framework and this work is being progressed by NatureScot.

[91] National Soil Inventory of Scotland (NSIS 1978-88) | Scotland's soils (Accessed May 2026)
[92] https://sefari.scot/sites/www.sefari.scot/files/2025-09/ENRA_Soil_Data_Resources_Paterson_et_al.pdf (Accessed May 2026)
[93] Measuring the vulnerability of Scottish soils to a changing climate (Accessed May 2026)
[94] scottish-biodiversity-delivery-plan-20242030.pdf (Accessed May 2026)

In March 2026, Scottish Government released initial development plans for new Official Statistics on Scotland's Peatlands[95]. The peatland statistics will be developed by Scottish Government's Rural and Environment Science and Analytical Services Division (RESAS) incrementally with stakeholder engagement. As outlined by Peatland ACTION's Five Year Partnership Plan 2025-2030[96], the plan is the first in a series of rolling five-year plans designed to deliver Scotland's long-term vision for peatland restoration.

While acknowledging that there are specific properties of peatlands (such as water table depth) that are important for understanding peatland restoration, the monitoring of peatlands could be integrated into the wider soil monitoring. This will ensure that the full range of soils from deep peats to peaty soils with differing drainage characteristics are properly represented within a monitoring framework.

7.2.3 Monitoring soils in the context of the wider environment

It is important to align the soil monitoring framework to wider environmental monitoring. This section examines the different data sources that are currently available for different contexts.

7.2.3.1 Soil sealing and urban expansion

Soil sealing is one of NatureScot's indicators of built environment pressures derived from analysis of Ordnance Survey MasterMap Greenspace[97] (a commercially available map and database of fixed features) and broadly follows the typology used in Planning and Advice Note 65: Planning and Open Space[98] and NatureScot records of windfarm sites. There are opportunities to better monitor soil sealing/urban expansion in Scotland (for example through satellite imagery) and relate this to landscape scale changes in soil resources and ecosystem services.

7.2.3.2 Assessments of contaminated land

There is ongoing discussion around responsibility for the identification of contaminated land (Section 4.1.1.1). Sites where local authorities have confirmed the presence of contamination are publicly available (e.g., central repository such as Spatial Hub[99]). However public records show sites of confirmed contamination and do not indicate sites that have not yet been confirmed, i.e., sites of potential contamination.

7.2.3.3 Environmental Impact Assessments

In Scotland, there is no central registry of EIAs from development applications. EIA associated with energy-related developments are available through the Energy Consents Unit [100]. Other documentation may be held across individual local authority (and other planning authority) on-line portals and so it is unclear the extent to which there may be

[95] Developing Official Statistics on Scotland's Peatlands - gov.scot (Accessed May 2026)
[96] Peatland ACTION Five Year Partnership Plan 2025-2030 (Accessed May 2026)
[97] https://www.nature.scot/professional-advice/placemaking-and-green-infrastructure/greenspace-map (Accessed May 2026)
[98] Contents - Planning advice note 65: planning and open space - gov.scot (Accessed May 2026)
[99] Contaminated Land - Scotland - Dataset - Spatial Hub Scotland (Accessed May 2026)
[100] https://www.energyconsents.scot/ (Accessed May 2026)

valuable soil information these may contain. Scottish EIA data is divided by sector (planning, agriculture, forestry) and maintained by the relevant consenting authority. Therefore, EIAs relating to planning applications will be held by LAs. Agricultural EIA register is[101] maintained by Scottish Governments Rural Payments and Inspections Division. For Forestry, Forest Scotland provide public records of EIA application details on their Public Register of EIA screening opinions with open access to Current Applications for EIA Con[102]sent and Historic Applications for EIA Consent[103].

7.2.3.4 Monitoring emerging contaminants and forever chemicals

There is growing awareness of the presence of emerging contaminants in Scotland (e.g. Helwig et al 2024[52]). Continued support to expand experimental evidence available is also needed to understand the release of contaminants into other parts of the environment including plants and waters.

7.2.3.5 Collating data from the Whole Farm Plan

There are opportunities to collate and store data gathered from the Whole Farm Plan in order to monitor progress and feed into national monitoring for changes in soil health with the adoption of different land management practices. This could, in turn, further incentivise the adoption of Scottish Government Agricultural Reform Measures[104] to address climate mitigation, adaption and nature restoration.

7.2.3.6 Use of remote sensing to assess soil management in the context of diffuse pollution and habitat management

Data and information derived from the use of remote sensing imagery such as satellite and airborne (aircraft/drones) sensors can provide valuable contribution to the monitoring and mapping of soils particularly across regional and national geographical scales. Light Detection and Ranging (LiDAR) uses lasers mounted on special aircraft to boost three-dimensional mapping[105]. The Scottish Government has recently funded a national LiDAR programme[106] to generate high resolution digital surface models to help understand environmental and agricultural issues, such as mapping the state of Scotland's peatlands, woodlands and forests to support and inform progress towards national climate, tree planting and nature restoration objectives. The Agri-Food and Bioscience Institute (AFBI)[107] in Northern Ireland have demonstrated the benefits of LiDAR application through improved mapping of soil runoff potential and high-risk flow pathways. When combined with data

[101] https://www.ruralpayments.org/topics/inspections/all-inspections/cross-compliance/environmental-impact-assessment/public-register/ (Accessed May 2026)

[102] scottishforestry-publicregister.oncreate.app/w/webpage/prhome-pep?webpage_subpage_id=PAG0000236GBLNM1&webpage_token=eb1df62ac093774cad10b1decb59d7739b25c61d88b30cfa77d60fb2f718fc74 (Accessed May 2026)

[103] https://www.forestry.gov.scot/historic-eia-cases (Accessed May2026)

[104] https://www.ruralpayments.org/topics/agricultural-reform-programme/arp-list-of-measures/ (Accessed May 2026)

[105] https://blogs.gov.scot/digital/2026/01/29/scotlands-lidar-revolution-first-data-release-to-reveal-scotlands-landscape-in-unprecedented-detail/ (a

[106] Scottish Land LiDAR Programme - 2025 capture - LAS - Dataset - data.gov.uk (Accessed May 2026)

[107] https://www.afbini.gov.uk/news/soil-nutrient-health-scheme-research-maps-way-ahead (Accessed May 2026)

from Northern Ireland's soil nutrient health scheme[108], there are opportunities to better identify areas that may require diffuse pollution mitigation to be adopted. The use of LiDAR data could also contribute to multivariate modelling of soil functions to explore the connectivity of soils with wider environmental monitoring (e.g. water flow, habitat extent and habitat condition) and mapping including the land cover maps used in the supporting evidence for Scotland's forth Land Use Strategy Scotland's fourth Land Use Strategy[109] to support decision making related to natural capital condition and NbS.

7.2.3.7 Third party soil data

As companies engage with mandatory and voluntary nature-related corporate reporting frameworks, so too does the investment into measuring and monitoring to support baseline reporting and the need to verify changes over time. For example, monitoring peatland restoration projects, conducting natural capital accounting and soil surveys for land capability assessments are often conducted in the private sector. Some form of access to this data would provide value to ongoing research and soil monitoring, but there are significant challenges with data confidentiality, governance and accessibility that restricts the potential to consolidate. In addition, extensive data collected through public research funding could be made publicly available for further analysis.

7.2.4 Soil monitoring across the EU

The EU Directive on Soil Monitoring and Resilience (Soil Monitoring Law[31]) entered into force on 16 December 2025. This aims to address key soil threats in the EU, such as soil erosion, loss of soil organic matter, contamination, compaction and sealing and the loss of soil biodiversity. Article 1 of The Directive lays down a framework for and measures on:

(a) monitoring and assessment of soil health;
(b) soil resilience;
(c) management of contaminated sites.

The Directive acknowledges that a monitoring framework is required to better understand both the extent of soil degradation and the effectiveness of measures put in place to restore soil health. Article 6 outlines that EU Member States will establish an appropriate soil monitoring framework[110]. The core areas of soil security and soil health are key strategic objectives within the current Scottish Soil Framework (2009). Therefore, developments made in EU implementation present an opportunity for Scotland to apply shared learning.

7.3 Options for action for Theme 5

T5-O1. Review strategic objectives in the soil framework:

Develop clear objectives and questions that can be addressed through soil monitoring with soil indicators and the use of existing data sets from national to plot scale data. A key

[108] Soil Nutrient Health Scheme Overview | Agri-Food and Biosciences Institute (Accessed May 2026)
[109] Supporting Evidence for Scotland's 4th Land Use Strategy (Accessed May 2026)
[110] Building on existing monitoring frameworks at national and Union level for soil health (on a soil unit basis) and soil sealing or removal (at a soil district level). https://ai4soilhealth.eu/a-framework-for-monitoring-and-assessing-soil-health-at-national-level/ (Accessed May 2026)

publication to assist this is the LUNZ 4 Nations soil monitoring report (Loades et al., 2026[Error! Bookmark not defined.]).

T5-O2. Support the design of a monitoring framework based on the integration of data sets from different sources:

Scotland's soil legacy data such as the National Soil Inventory of Scotland (NSIS) is a valuable tool in developing baselines against which change can be measured. This includes exploring how these can be combined with new data using the most appropriate statistical techniques to answer specific questions aligned to strategic objectives for Scottish Soils. This includes the integration of peatland monitoring into a wider soil monitoring framework.

T5-O3. Develop research to provide robust scientific data to support the use of novel indicators in soil monitoring:

There have been several reviews of data and indicators for monitoring soils. This includes the use of data from intensively monitored sites designed to link changes in these indicators to changes in soil function. Novel indicators include those from soil biology and those measuring emerging contaminants.

T5-O4. Review the potential for collation and use of supplementary data:

This includes exploring opportunities to access data that will be collected as part of the Whole Farm Plan and explore other potential data sources, such as soil data collected as part of LCA and EIAs and monitoring conducted by commercial companies for corporate reporting purposes.

T5-O5. Support Scotland's Soil Website to host soil data, guidance and tools:

This platform provides access to soils data for a wide range of public and commercial stakeholders. Provision of guidance would support understanding and appropriate use of data and highlight limitations. This could include guidance for plot scale use such as guidelines for LCA field assessments and data collected by farmers as part of the whole farm plan.

8 Mobilising soil protection, restoration and enhancement in Scotland

This report proposes a range of options that could initiate progress for further soil protection, restoration and enhancement in Scotland. These are presented in Table 6which indicates the readiness to implement each option and how they support the delivery of multiple Scottish policies.

Further detail is provided in Appendix F2, which highlights how different nature-based Scottish Government policies and strategies can address various risks to soils with Table 6 showing direct and indirect links to support these different policy areas. For example, Appendix F3 highlights how PREn1 options for action can directly support the delivery of the Scottish Biodiversity Delivery Plan 2024–2030[94].

Table 6. Initial objectives and options for action suggested within the Soil Route Map for Scotland with an indication of how they contribute to the delivery of Scottish nature-focused policies

	Actions are already in progress or could be readily initiated with some investment of resources		These options would need more research and/or resources to initiate		These options are likely to have a direct contribution to policy delivery		These options are likely to have an indirect contribution to policy delivery

		Where options for action could contribute to policy delivery					
Options for action		**Climate & circularity**	**Biodiversity & Nature**	**Agriculture & Food security**	**Peatland & Forestry**	**Water & catchment management**	**Planning & developments**
T1-O1	Develop Scotland-specific guidance to support soil protection, restoration and enhancement in Local Development Plans (LDPs)	Protection and enhancement of soil carbon stores	Protecting soils will support habitat resilience	Protect prime agricultural land	Better protect priority peatlands	Protecting soils contributes to NbS	Support the delivery of NPF4-policy 5
T1-O2	Expand guidance for identifying and protecting carbon-rich soils	Protection and enhancement of soil carbon stores	Protecting soils will support habitat resilience		Contribute to the protection of peat soils	Protecting soils contributes to NbS	Support the delivery of NPF4-policy 5
T1-O3	Develop targeted guidance for conducting Land Capability for Agriculture (LCA) assessments		Protecting soils will support habitat resilience	Protect prime agricultural land		Protecting soils contributes to NbS	Support the delivery of NPF4-policy 5
T1-O4	Review and develop guidance of soils within EIAs	Protection and enhancement of soil carbon stores	Protecting soils will support habitat resilience	Protect prime agricultural land	Protect priority peatlands & contribute to NbS	Protecting soils contributes to NbS	Support the delivery of NPF4-policy 5

Options for action		Where options for action could contribute to policy delivery					
		Climate & circularity	**Biodiversity & Nature**	**Agriculture & Food security**	**Peatland & Forestry**	**Water & catchment management**	**Planning & developments**
T1-O5	Review opportunities to better link the sustainable management of soils during development projects to support wider environmental net gains	Protection and enhancement of soil carbon stores	Protecting soils will support habitat resilience	Protect prime agricultural land	Protect peatlands and carbon rich soils /potential for woodland creation	Soil management for water quality and water flow (flood/drought)	Support the delivery of NPF4-policy 5
T1-O6	Develop procedures which promote the sustainable use and reuse of Scottish soils	Contributes to circularity objectives and contributes to soil carbon storage potential	Soil resources support natural Scotland's capital and biodiversity	Reusing healthy soils can support Scotland's productivity	Contributes to conserving peat and forest soils	Soils contribute to water movement, holding capacity and cycling and therefore water quantity and quality	Reusing soils during construction contributes to the sustainability of a development project
T2-O1	Develop cross-sector guidance on soil compaction and soil physical degradation	Alleviate soil compaction and reduce soil physical degradation to conserve soil functions & and mitigate impacts on ecosystem services.					
T2-O2	Explore opportunities for soil compaction to be identified and alleviated through existing programmes	The delivery of soil compaction management will directly mitigate the consequences of soil compaction including on water quality, flooding, food security and GHG emissions.					
T2-O3	Update guidance and tools informing the risk of Scottish soils to physical degradation and compaction	Further understanding of soil vulnerability and risks to physical degradation and compaction will contribute to nature recovery and understanding soil as a natural capital asset.					

Options for action		Where options for action could contribute to policy delivery					
		Climate & circularity	**Biodiversity & Nature**	**Agriculture & Food security**	**Peatland & Forestry**	**Water & catchment management**	**Planning & developments**
T3-O1	Support the identification and remediation of contaminated soils	Healthier soils for climate mitigation and adaptation	Healthier soils to support diverse habitats			Healthier soils to reduce diffuse pollution	Support NPF4 – Policy 9
T3-O2	Review and further develop guidance to support nutrient management planning in agriculture	Reduce terrestrial GHG emissions derived from excess nutrients		Reduce dependency on chemical fertilisers		Reduce leaching of excess nutrients	
T3-O3	Develop research and guidance on the application or soil amendments for nutrient management	Understand the impacts of amendments to circularity and soil health without damaging soils.	Understand the impacts of amendments on wider biodiversity and nature	Understand the contribution to soil health without leading to contamination.		Understand soil amendment impacts on ground and surface water	
T3-O4	Monitor progress of the Whole Farm Plan	Identify mechanisms that are contributing to climate mitigation and adaptation	Identify mechanisms that are contributing to biodiversity and nature benefits	Data to support future research, soil monitoring, national models, policy and decision-making		Identify mechanisms that are contributing to changes in water quality and quantity	
T3-O5	Advance research on forever chemicals and emerging contaminants in Scottish soils		Healthier soils to support healthier habitats, peatlands, forests and woodlands and food production				

Options for action		Where options for action could contribute to policy delivery					
		Climate & circularity	**Biodiversity & Nature**	**Agriculture & Food security**	**Peatland & Forestry**	**Water & catchment management**	**Planning & developments**
T4-O1	Continued support for peatland restoration and woodland creation	Contributes to carbon storage and climate mitigation	Peatlands and forest soils can contribute to biodiversity and nature resilience		Contributes to conserving and enhancing peatlands and forest soils	Peatlands and forest soils can contribute to NbS	
T4-O2	Review policies for aligning a soil monitoring framework with environmental sustainability reporting standards	Can support further private investment relating to sustainable soil management					
T4-O3	Review policies for aligning a soil monitoring framework with nature-based frameworks	Can support further private investment relating to sustainable soil management					
T4-O4	Develop guidance on appropriate use and limitations of soil metrics in corporate reporting and verification	Supports appropriate use of soil data and the potential for combining it to improve the understanding and modelling of soil functions and impacts of changes in soil health to wider ecosystem services.					
T4-O5	Review the guidance and incentivise further mobilisation of soil protection, restoration and enhancement through the adoption of financial frameworks	Nature-related financial disclosure frameworks offer holistic assessment (dual materiality) of a business' interaction with nature to mitigate negative implications					
T5-O1	Review strategic objectives in the soil framework	Clarity and agreement in soil monitoring framework objectives will provide direction to progress forward and refine indicators sample points and wider scientific objectives that can be addressed by data collection.					
T5-O2	Support the design of a monitoring framework based on the integration of data sets from different sources	Use research on combining data from different sources within a monitoring framework to support future research, soil monitoring, national models, practical application, policy making and decision-making					

Options for action		Where options for action could contribute to policy delivery					
		Climate & circularity	**Biodiversity & Nature**	**Agriculture & Food security**	**Peatland & Forestry**	**Water & catchment management**	**Planning & developments**
T5-O3	Develop research to provide robust scientific data to support the use of novel indicators in soil monitoring	Build and understanding of the application of novel indicators and how they can support understanding changes in soil and soil functions modelling of future scenarios and impacts of threats to soils, local decision-making and policy development.					
T5-O4	Review the potential for collation and use of supplementary data	Can inform on future developments of the soil monitoring framework and provide supplementary data to inform on wider environmental issues.					
T5-O5	Support Scotland's Soil Website to host soil data, guidance and tools	Use Scotland's Soils Website and apps to provide data, tools to inform decision making and information on specific properties and risks.					

8.1 Potential pathways to implementation

Soils are a core natural capital asset and so inextricably linked to Scotland's net zero targets, biodiversity delivery plan, flood resilience and water quality. The Scottish National Adaptation Plan 2024-2029[2] recognises the crucial importance of a healthy natural environment in supporting Scotland's resilience to climate change. A key priority is to build resilience against multiple and cascading risks by managing water and soil as our primary natural assets.

There is no 'one rule fits all' that would address the challenges identified to 'protect, restore and enhance' Scottish soils. However, the mitigation hierarchy is a useful, universal tool to help navigate measures to avoid, minimise, restore and enhance soils. A shared cross-sectoral goal is to achieve healthy and resilient soils, but what does this look like across different sectors and land uses?

The principles within the mitigation hierarchy are core to the NPF4 strategy, although readily used in planning applications it is not commonly referred to in the context of agricultural or peatland management. This framework provides an opportunity for land managers to reflect on each management decision – firstly considering whether soil impacts can be avoided and if not, reviewing options to minimise any negative consequences (Figure 4). For example, in an agricultural context this can be applied (alongside compliance[26] requirements and other guidance) in terms of identifying ways farmers and crofters assess their land management practices and review where there are options to avoid, reduce, retore and enhance. This approach would also align well with EIAs.

There are also opportunities to align the route map objectives to corporate frameworks relating to carbon and nature management within environment, social and governance (ESG) goals. This would help to leverage and support private sector input to drive soil security in Scotland. Taking a natural capital approach to soil management offers the benefit of aligning to wider ecosystem service benefits (and policy themes) such as climate mitigation and adaptation, water management in terms of resilience to flood/drought as well as safeguarding water quality.

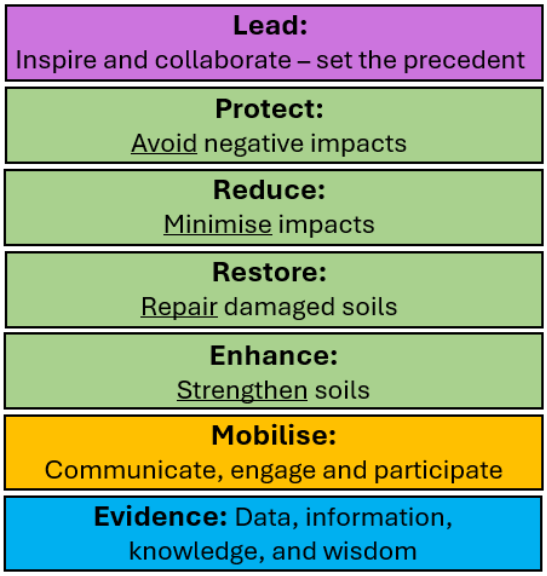

Figure 4. Objectives of the Soil Route Map for Scotland 2026

9 Next Steps and Conclusions

The soil route map outlines key objectives and initial options for action to accelerate soil protection, restoration and enhancement in Scotland to achieve thriving soils for Scotland's community, environment and economy. Underpinning the mobilisation of activities is leadership and evidence and this research emphasises the value of concerted action across all stakeholders in the coming years.

In March 2026, Scottish Government announced their Environment, Natural Resources and Agriculture Research Strategy 2027 to 2032[111] outlining a range of missions that Scottish Government will strive to achieve and the areas of research identified as being fundamental to addressing specific environmental challenges. With respect to soils, the strategy outlines specific research aims shown in Table 7 to address the mission of 'restoring nature and protecting our environment'.

Table 7. Soil specific areas of research interests outlined in the Environment, Natural Resources and Agriculture Research Strategy 2027 to 2032.

Challenge	Areas of Research Interest
Protecting and restoring Scotland's soils	What soils data, metrics, and other information do we need, across the full continuum of Scotland's soils from mineral to deep peats, to understand the current land status and to develop policy-relevant insights?
	What is the impact of climate change, extreme weather and variability on soil function, across the full continuum of Scotland's soils from mineral to deep peats, and its relation to water and biodiversity?
	What does healthy soil biodiversity and biological activity look like for different ecosystems and land management systems (for example, including agricultural, urban, semi-natural and peatland)?
Protecting and restoring Scotland's peatlands	What does successful peatland restoration look like, now and in the medium and long-term?
	Which peatland data gaps should be addressed as a priority?
	How does renewable and other energy infrastructure impact carbon rich soils in Scotland?

Areas of interest include developing soil monitoring capabilities, exploring impacts of climate change on soil functions and wider environmental conditions (e.g., biodiversity and water) and peatland restoration. Wider areas of research interest outlined in Scottish Government's Environment, Natural Resources and Agriculture Research: Strategy 2027 to 2032[17] that directly and indirectly support future progression of soil knowledge in Scotland are described in Appendix G1.

The Soil Route Map[1], Scottish Government's Environment, natural resources and agriculture: strategic research programme 2022-2027[58] and the strategy for work to 2032[17] provide a platform for soil specific policy delivery (e.g. Soil-specific objectives in the Scottish

[111] Environment, Natural Resources and Agriculture Research: Strategy 2027 to 2032 - gov.scot (Accessed May 2026)

Biodiversity Delivery Plan 2024–2030[56] outlined in Appendix G2). They support policy developments for Scottish soils going forward, such as a formal update of the Scottish Soil Framework (2009)[90] as a key step forward for achieving thriving soils for Scotland's communities, environment and economy.

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Appendix A – Supplementary background information

A1: Overarching objectives of the Soil Route Map for Scotland

Six objectives outlined in "Securing soils in a changing climate: A soil route map for Scotland" 2025[1] to achieve thriving soils for Scottish environment, communities and economy

A2: Risks to Scottish soils

Risks to Scottish soils outlined in "Securing soils in a changing climate: A soil route map for Scotland" 2025[1]

Soil Issue	Scottish Soil Framework (2009)	Environmental Standards Scotland Report (2024)
Climate change impacts on soil	1	–
Loss of organic matter and carbon	2	Medium
Soil sealing	3	Low
Acidification and eutrophication	4	–
Loss of soil biodiversity	5	High
Soil contamination	6	Medium
Soil erosion and landslide	7	High
Pesticide application	8	–
Soil compaction	9	High
Salinisation	10	–
Risks from the inconsistent approaches to data collection and monitoring	–	High
Risks from carbon sequestration schemes	–	Medium
Water retention/capacity of soils	–	Medium
Application of waste to land	–	Medium
Landfilling of waste soil	–	Medium
Soilborne diseases and pests	–	Low

A3: Stakeholder feedback to the 2025 report

As part of this process, stakeholder feedback was welcomed to further inform next steps taken by Scottish Government. The survey had 10 responses 6 from academia, 1 land manager and 3 other respondents identifying as 'charity' and 'commercial' backgrounds. Feedback was overall positive with respondents highlighting key specific opportunities and considerations. For example, Scotland has an opportunity to lead in soil monitoring based on the data sets it has across all land covers as a baseline. It was acknowledged that reviewing developments in the EU could provide useful guidance for how Scotland develop a soil monitoring framework. Other considerations raised included considering the needs of people using the soils and to ensure that practitioners and land managers are included in the 'lead' component of the route map and that it supports communities and the economy. It was highlighted that a lack of expertise for soil classification and sampling that needs to be addressed to support the collection of future evidence needed. The need for long-term commitment in terms of funding soil monitoring to ensure there is a flow of data into research was also raised. Lastly, the prioritisation of objectives would help in the consideration of trade-offs for wider societal and environmental benefits.

A4: Sources used to develop glossary

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Appendix B – Supplementary information for Theme 1 - Soil sealing and soils in the built environment

Please note, information presented was accessed May 2026, however some documents referenced here are subject to change as guidance is updated. Please check for latest available versions of sources reported here.

B1: Impacts of soil sealing on soil ecosystem services

An overview of key ecosystem services affected by soil sealing, as described by FAO, 2015[112]

Impacts of sealing soils	**Ecosystem services (as described by FAO, 2015[112])**
Loss of productivity as crops and plants have limited access the soil medium, nutrients and water	Provision of food fibre and fuel
Degradation of soil health. Covering soils affects soil structure, impedes gas exchange and affects nutrient cycling	Nutrient cycling and carbon sequestration
Reduced carbon sequestration potential	Carbon sequestration, climate regulation, nutrient cycling
Increased flood risk due to increased surface runoff and lower interception and water holding capacity. Loss of soil sequestration potential exacerbates climate regulation function	Climate regulation, flood regulation
Water quality is affected due to increased runoff from urban surfaces (e.g. roads)	Water purification and soil contaminant reduction
Loss of biodiversity. Soil degradation from sealing can lead to a decline in soil biodiversity and the above-ground biodiversity it supports	Habitat for organisms. Source of pharmaceuticals and genetic sources
Soil sealing can have negative impacts on local archaeology and cultural heritage	Cultural heritage. Source of pharmaceuticals and genetic sources

B2: Local Development Plans for Sustainable Places

Requirements and considerations for LPDs outlined in Policies 1-13 in NPF4[5] 'Sustainable Places'

[112] https://openknowledge.fao.org/server/api/core/bitstreams/5934eac5-9dfd-4c09-85be-693e4b59a7cc/content (Accessed May 2026)

NPF4 Policy	Stipulated requirements for LDPs
1: Tacking climate and nature crises	LDPs must address the global climate emergency and nature crisis by ensuring the spatial strategy will reduce emissions and adapt to current and future risks of climate change by promoting nature recovery and restoration in the area.
2: Climate mitigation and adaptation	The LDP spatial strategy should be designed to reduce, minimise or avoid greenhouse gas emissions. The six spatial principles should form the basis of the spatial strategy, helping to guide development to, and create sustainable locations. The strategy should be informed by an understanding of the impacts of the proposals on greenhouse gas emissions. LDPs should support adaptation to the current and future impacts of climate change by taking into account climate risks, guiding development away from vulnerable areas, and enabling places to adapt to those risks.
3: Biodiversity	LDPs should protect, conserve, restore and enhance biodiversity in line with the mitigation hierarchy. They should also promote nature recovery and nature restoration across the development plan area, including by facilitating the creation of nature networks and strengthening connections between them to support improved ecological connectivity; restoring degraded habitats or creating new habitats; and incorporating measures to increase biodiversity, including populations of priority species.
4: Natural places	LDPs will identify and protect locally, regionally, nationally and internationally important natural assets, on land and along coasts. The spatial strategy should safeguard them and take into account the objectives and level of their protected status in allocating land for development. Spatial strategies should also better connect nature rich areas by establishing and growing nature networks to help protect and restore the biodiversity, ecosystems and natural processes in their area.
5: Soils	LDPs should protect locally, regionally, nationally and internationally valued soils, including land of lesser quality that is culturally or locally important for primary use.
6: Forestry, woodland and trees	LDPs should identify and protect existing woodland and the potential for its enhancement or expansion to avoid habitat fragmentation and improve ecological connectivity, helping to support and expand nature networks. The spatial strategy should identify and set out proposals for forestry, woodlands and trees in the area, including their development, protection and enhancement, resilience to climate change, and the expansion of a range of types to provide multiple benefits. This will be supported and informed by an up-to-date Forestry and Woodland Strategy

NPF4 Policy	Stipulated requirements for LDPs
7: Historic assets and places	LDPs, including through their spatial strategies, should support the sustainable management of the historic environment. They should identify, protect and enhance valued historic assets and places.
8: Green belts	LDPs should consider using green belts, to support their spatial strategy as a settlement management tool to restrict development around towns and cities. Green belts will not be necessary for most settlements but may be zoned around settlements where there is a significant danger of unsustainable growth in car-based commuting or suburbanisation of the countryside. Green belts should be identified or reviewed as part of the preparation of LDPs. Boundary changes may be made to accommodate planned growth, or to extend, or alter the area covered as green belt. Detailed green belt boundaries should be based on evidence and should be clearly identified in plans
9: Brownfield, vacant and derelict land and empty buildings	LDPs should set out opportunities for the sustainable reuse of brownfield land including vacant and derelict land and empty buildings
10: Coastal development	LDP spatial strategies should consider how to adapt coastlines to the impacts of climate change. This should recognise that rising sea levels and more extreme weather events resulting from climate change will potentially have a significant impact on coastal and islands areas and take a precautionary approach to flood risk including by inundation. Spatial strategies should reflect the diversity of coastal areas and opportunities to use nature-based solutions to improve the resilience of coastal communities and assets. LDP spatial strategies should identify areas of developed and undeveloped coast and should align with national, sectoral and regional marine plans.
11: Energy	LDPs should seek to realise their area's full potential for electricity and heat from renewable, low carbon and zero emission sources by identifying a range of opportunities for energy development.
12: Zero waste	LDPs should identify appropriate locations for new waste management infrastructure to support the circular economy and meet identified needs in a way that moves waste as high up the waste hierarchy as possible

NPF4 Policy	Stipulated requirements for LDPs
13: Sustainable transport	LDPs should prioritise locations for future development that can be accessed by sustainable modes. The spatial strategy should reflect the sustainable travel hierarchy and sustainable investment hierarchy by making best use of existing infrastructure and services. LDPs should promote a place-based approach to consider how to reduce car-dominance. This could include low traffic schemes, shared transport options, designing–in speed controls, bus/cycle priority, pedestrianisation and minimising space dedicated to car parking. Consideration should be given to the type, mix and use of development; local living and 20-minute neighbourhoods; car ownership levels; the accessibility of proposals and allocations by sustainable modes; and the accessibility for users of all abilities. LDPs should be informed by an appropriate and effective transport appraisal undertaken in line with relevant transport appraisal guidance. Plans should be informed by evidence of the area's transport infrastructure capacity, and an appraisal of the spatial strategy on the transport network. This should identify any potential cumulative transport impacts and deliverable mitigation proposed to inform the plan's infrastructure first approach. Where there is likely to be an impact on the trunk road or rail network, early engagement with Transport Scotland is required.

B3: NPF4 Policy 5

Summary of NPF4's Policy 5[5], which has the intention to protect carbon-rich soils, restore peatlands and minimise disturbance to soils from development.

Policy	Description of Policy
5a) Development proposals will only be supported if they are designed and constructed	i. In accordance with the mitigation hierarchy by first avoiding and then minimising the amount of disturbance to soils on undeveloped land; and
	ii. In a manner that protects soil from damage including from compaction and erosion, and that minimises soil sealing
5b) Development proposals on prime agricultural land, or land of lesser quality that is culturally or locally important for primary use, as identified by the LDP, will only be supported where it is for:	i. Essential infrastructure and there is a specific locational need and no other suitable site;
	ii. Small-scale development directly linked to a rural business, farm or croft or for essential workers for the rural business to be able to live onsite;
	iii. The development of production and processing facilities associated with the land produce where no other local site is suitable;
	iv. The generation of energy from renewable sources or the extraction of minerals and there is secure provision for restoration; and in all of the above exceptions, the layout and design of the proposal minimises the amount of protected land that is required.
5c) Development proposals on peatland, carbon rich soils and priority peatland habitat will only be supported for:	i. Essential infrastructure and there is a specific locational need and no other suitable site;
	ii. The generation of energy from renewable sources that optimises the contribution of the area to greenhouse gas emissions reductions targets;
	iii. Small-scale development directly linked to a rural business, farm or croft; iv. Supporting a fragile community in a rural or island area; or
	v. Restoration of peatland habitats.
5d) Where development on peatland, carbon-rich soils or priority peatland habitat is proposed, a detailed site-specific assessment will be required to identify:	i. the baseline depth, habitat condition, quality and stability of carbon rich soils;
	ii. the likely effects of the development on peatland, including on soil disturbance; and
	iii. the likely net effects of the development on climate emissions and loss of carbon. This assessment should inform careful project design and ensure, in accordance with relevant guidance and the mitigation hierarchy, that adverse impacts are first avoided and then minimised through best practice. A peat management plan will be required to demonstrate that this approach has been followed, alongside other appropriate plans required for restoring and/ or enhancing the site into a functioning peatland system capable of achieving carbon sequestration.
5e) Development proposals for new	i. the extracted peat is supporting the Scottish whisky industry;
	ii. there is no reasonable substitute;

Policy	Description of Policy
commercial peat extraction, including extensions to existing sites, will only be supported where:	iii. the area of extraction is the minimum necessary, and the proposal retains an in-situ residual depth of peat of at least 1 metre across the whole site, including drainage features;
	iv. the time period for extraction is the minimum necessary; and
	v. there is an agreed comprehensive site restoration plan which will progressively restore, over a reasonable timescale, the area of extraction to a functioning peatland system capable of achieving carbon sequestration.

B4: Soils in SEA and EIA – Institute of Sustainability and Environmental Professionals/IEMA (2022)

At the strategic level, any public sector plans, strategies, and programmes that affect the environment must go through a Strategic Environmental Assessment (SEA), which includes considering the impact on soil. This process is designed to judge the likely impact of a public plan on the environment and to seek ways to minimise that effect (SEA Guidance[113]). Sizable projects, which fall within Schedule 1 to the 2017 EIA Regulations[114], will require an Environmental Impact Assessment (EIA). A summary of how soils are considered within the Institute of Sustainability and Environmental Professionals (ISEP), formally the Institute of Environmental Management & Assessment (IEMA) Guide: A New Perspective on Land and Soil in Environmental Impact Assessment (2022)[8]

B4(a) - Summary receptor sensitivity focusing on Scottish context

Receptor Sensitivity (in-situ soils)	Very High	High	Medium	Low
Biomass production (LCA Class)	1 & 2	3.1	3.2	4.1 to 7
Soil carbon	Peat soil	Organo-mineral (peaty) soil	Mineral soils	Mineral soils
Ecological habitat, soil biodiversity and platform for landscape	Soils supporting protected features within an EU site	Soils supporting protected features within a UK designated site	Soils supporting protected or valued features within non-statutory designated sites	Soils supporting valued features within non-designated notable or priority habitats/ landscapes

[113] Strategic Environmental Assessment: guidance - gov.scot (Accessed May 2026)

[114] The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Accessed May 2026)

Archaeology, Cultural heritage, Community benefits and Geodiversity	Known	Probable	Possible	No notable
Soil hydrology: catchment pathway** for water flows and flood risk management	Very important	Important	Important minor	Pathway
Source of materials	Important surface mineral reserves that would be sterilised (i.e., without future access)	Surface mineral reserves that would be sterilised (i.e. without future access	Surface mineral reserves that would remain accessible for extraction	Surface mineral reserves that would remain accessible for extraction

**As defined by the site and catchment characteristics according to the professional judgement of a catchment hydrologist

B4(b) - Assessing the magnitude of impact (change) on soils in the IEMA (2022)[8] guidance

Magnitude of Impact (Change)	**Description of Impacts Restricting Proposed Land Us**
Major	Permanent, irreversible loss of one or more soil functions or soil volumes (including permanent sealing or land quality downgrading), over an area of more than 20ha or loss of soil-related features set out in 11.4.1 above, as advised by other topic specialists in EIA team (including effects from 'temporary developments'*) *or* Potential for permanent improvement in one or more soil functions or soil volumes due to remediation or restoration over an area of more than 20ha, or gain in soil-related features set out in 11.4.1 above, as advised by other topic specialists in EIA team (including effects from 'temporary developments'*)
Moderate	Permanent, irreversible loss of one or more soil functions or soil volumes, over an area of between 5 and 20ha or loss of soil-related features set out in 11.4.1 above, as advised by other topic specialists in EIA team (including effects from 'Temporary Developments'*) *or* Potential for improvement in one or more soil functions or soil volumes due to remediation or restoration over an area of between 5 and 20ha, or gain in soil-related features set out in 11.4.1 above, as advised by other topic specialists in EIA tea

Minor	Permanent, irreversible loss over less than 5ha or a temporary, reversible loss of one or more soil functions or soil volumes), or temporary, reversible loss of soil-related features set out in 11.4.1 above, as advised by other topic specialists in EIA team or Potential for permanent improvement in one or more soil functions or soil volumes due to remediation or restoration over an area of less than 5ha or a temporary improvement in one or more soil functions due to remediation or restoration or off-site improvement, or temporary gain in soil-related features set out in 11.4.1 above, as advised by other topic specialists in EIA team
Negligible	No discernible loss or reduction or improvement of soil functions or soil volumes that restrict current or proposed land use

* Temporary developments can result in a permanent impact if resulting disturbance or land use change causes permanent damage to soils

B4(c) - Assessing the sensitivity of topsoil and subsoils in the IEMA (2022)[8] guidance

Sensitivity of Topsoil and Subsoil	Soil Texture, Field Capacity Days and Wetness Class Characteristics
High sensitivity (low resilience to structural damage)	Soils with high clay and silt fractions (clays, silty clays, sandy clays, heavy silty clay loams and heavy clay loams) and organo-mineral and peaty soils where the FCD are 150 or greater. Medium-textured soils (silt loams, medium silty clay loams, medium clay loams and sandy clay loams) where the FCDs are 225 or greater. All soils in WCV or WCVI.
Medium sensitivity (medium resilience to structural damage)	Clays, silty clays, sandy clays, heavy silty clay loams, heavy clay loams, silty loams and organo-mineral and peaty soils where the FCDs are fewer than 150. Medium-textured soils (silt loams, medium silty clay loams, medium clay loams and sandy clay loams) where FCDs are fewer than 225. Sands, loamy sands, sandy loams and sandy silt loams where the FCDs are 225 or greater or are in WCIII and WCIV.
Low sensitivity (high resilience to structural damage)	Soils with a high sand fraction (sands, loamy sands, sandy loams and sandy silt loams) where the FCDs are fewer than 225 and are in WCI to WCII.

B5: Classes from the carbon and peatland map (2016)

Class		Class description	Indicative soil	Indicative vegetation
	1	Nationally important carbon-rich soils, deep peat and priority peatland habitat. Areas likely to be of high conservation value	Peat soil	Peatland
	2	Nationally important carbon-rich soils, deep peat and priority peatland habitat. Areas of potentially high conservation value and restoration potential	Peat soil with occasional peaty soil	Peatland or areas with high potential to be restored to peatland
	3	Dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Occasional peatland habitats can be found. Most soils are carbon-rich soils, with some areas of deep peat	Predominantly peaty soil with some peat soil	Peatland with some heath
	4	Area unlikely to be associated with peatland habitats or wet and acidic type. Area unlikely to include carbon-rich soils	Predominantly mineral soil with some peat soil	Heath with some peatland
	5	Soil information takes precedence over vegetation data. No peatland habitat recorded. May also include areas of bare soil. Soils are carbon-rich and deep peat.	Peat soil	No peatland vegetation
	0	Mineral soil - Peatland habitats are not typically found on such soils (Class 0)	Mineral soils	No peatland vegetation
	-1	Unknown soil type – information to be updated when new data are released (Class -1)	Not classified (unknown soil type)	Not applicable
	-2	Non-soil (e.g. loch, built up area, rock and scree) (Class -2)	No soil	Not applicable

B6: Peatlands and carbon-rich soils in EIA - NatureScot

NatureScot's requirements within EIA reporting to assess whether impacts on peatlands raise issues of national interest are explained in Annex 2 of the online guidance Advising on peatland, carbon-rich soils and priority peatland habitats in development management[10], NatureScot.

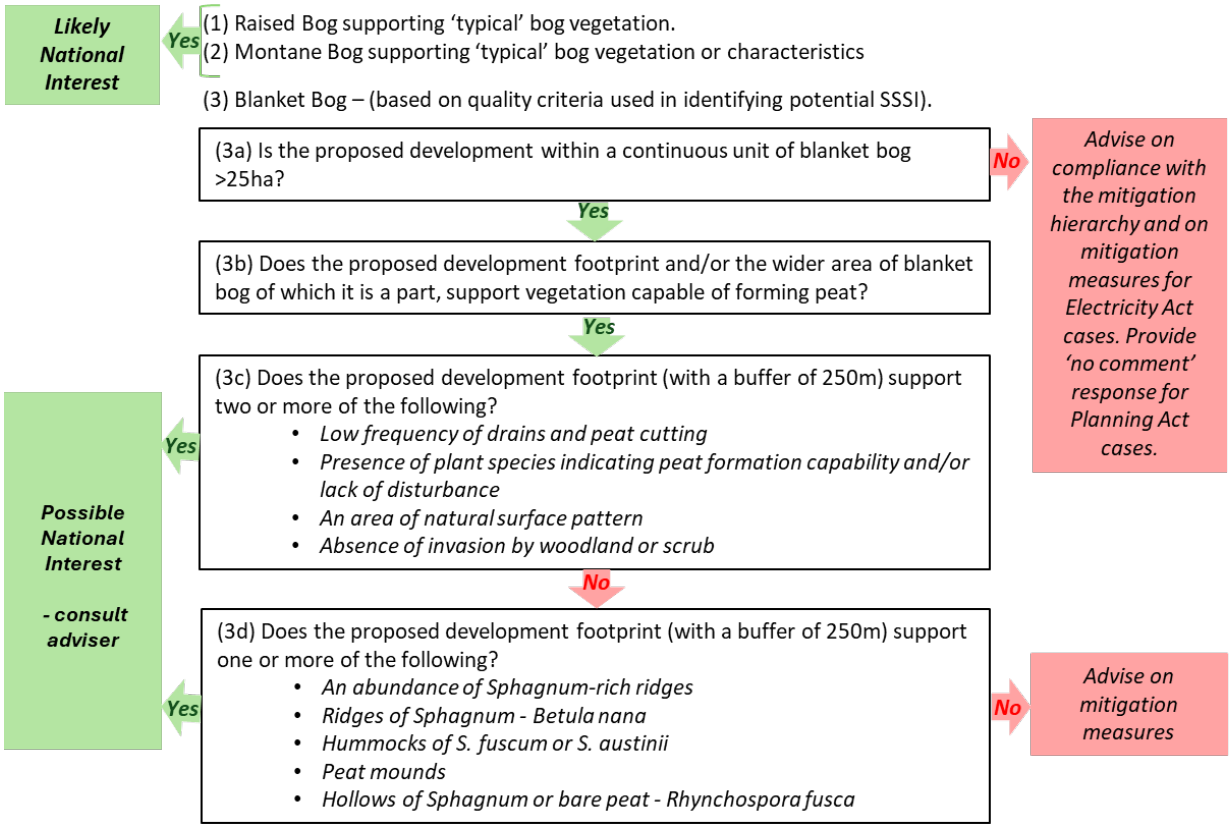
Report	Description
Peat depth survey,	This should be an overview of the whole site with a more detailed survey resolution where the infrastructure is proposed.
Habitat survey & report (NVC)	Interpretation of condition of peatland systems including information on erosion features as well as detail on the presence of topographical factors and species considered in Annex 1 of their guidance.
Habitat Management Plan (HMP), or outline HMP	Should contain enough detail to demonstrate that proposals for peatland restoration are likely to be effective. We advise the provision of information similar to that required for a Peatland Action application. For example, clear mapping of the condition of the peatland habitats (whether Near-Natural, Modified, Drained and Actively Eroding), identification of site-based restoration features (hags, gullies, peat dams etc), identification of a 'restoration footprint' around these features, based on identification of ditches to be blocked for example. The outline HMP should include information on past and current management, and proposals for future management including explanation of how grazing/browsing will be appropriately managed. It should describe the proposed restoration methods informed by best practice advice, including our website guidance on peatland restoration techniques, and particularly our technical compendium.
Peat Management Plan (PMP), or outline PMP	Should include detail on the extent of peat within the proposal, impacts and mitigation adopted to reduce impacts to peat soil and other carbon-rich soils. A table detailing the infrastructure and associated average peat depths, estimated volumes excavated and re-used should be detailed, as defined by SEPA to demonstrate the impacts on peat. The plan should also include detail on the temporary storage of peat soils, the habitat type and condition of the area on which they will be stored, as well as a consideration of the degradation of the quality of the material stored over time, with steps taken to ensure the peat remains in a reusable condition. Detail on the reuse of peat should indicate whether this will be in reinstatement, restoration, on-site offsetting, off-site offsetting or enhancement. Reuse of peat off-site in the offsetting plan will require consultation with SEPA.
Peat Landslide Hazard Risk Assessment (PLHRA).	This will contain detail on the quality and stability of carbon-rich soils, and information on extent and condition of drainage features. It is worth noting that a PLHRA applies to the risk of peat landslide, not all peatland instability. Information for peat creep and other minor instability can be accessed via the NatureScot[115] and Peatland Action[116] reports

[115] https://www.nature.scot/doc/naturescot-research-report-1259-risk-based-approach-peatland-restoration-and-peat-instability (Accessed May 2026)
[116] https://www.nature.scot/doc/peatland-action-technical-compendium (Accessed May 2026)

Construction Environmental Management Plan (CEMP),	This document should include detail on the design of the proposal, including any mitigation already applied to the project. Detail on the construction of the development as well as any safeguarding and reinstatement measures which will be adopted.

B7: Assessment criteria for peatland, carbon-rich soils and priority peatland habitats in development management

Flow chart outlining the key stages for assessing elements of the development mentioned in an EIA reporting. Adapted from Annex 1 of NatureScot's Advising on peatland, carbon-rich soils and priority peatland habitats in development management[10])



B8: Land Capability for Agriculture Scotland

Scotland's Soils Website provides 1:50 000 national LCA maps[16] and following extensive field verification and consultation with stakeholders The Land capability for agriculture (partial cover) map[16] provides information at a greater resolution (1:25 000), which shows the distribution of different land classes across of Scotland's cultivated agricultural land and adjacent uplands.

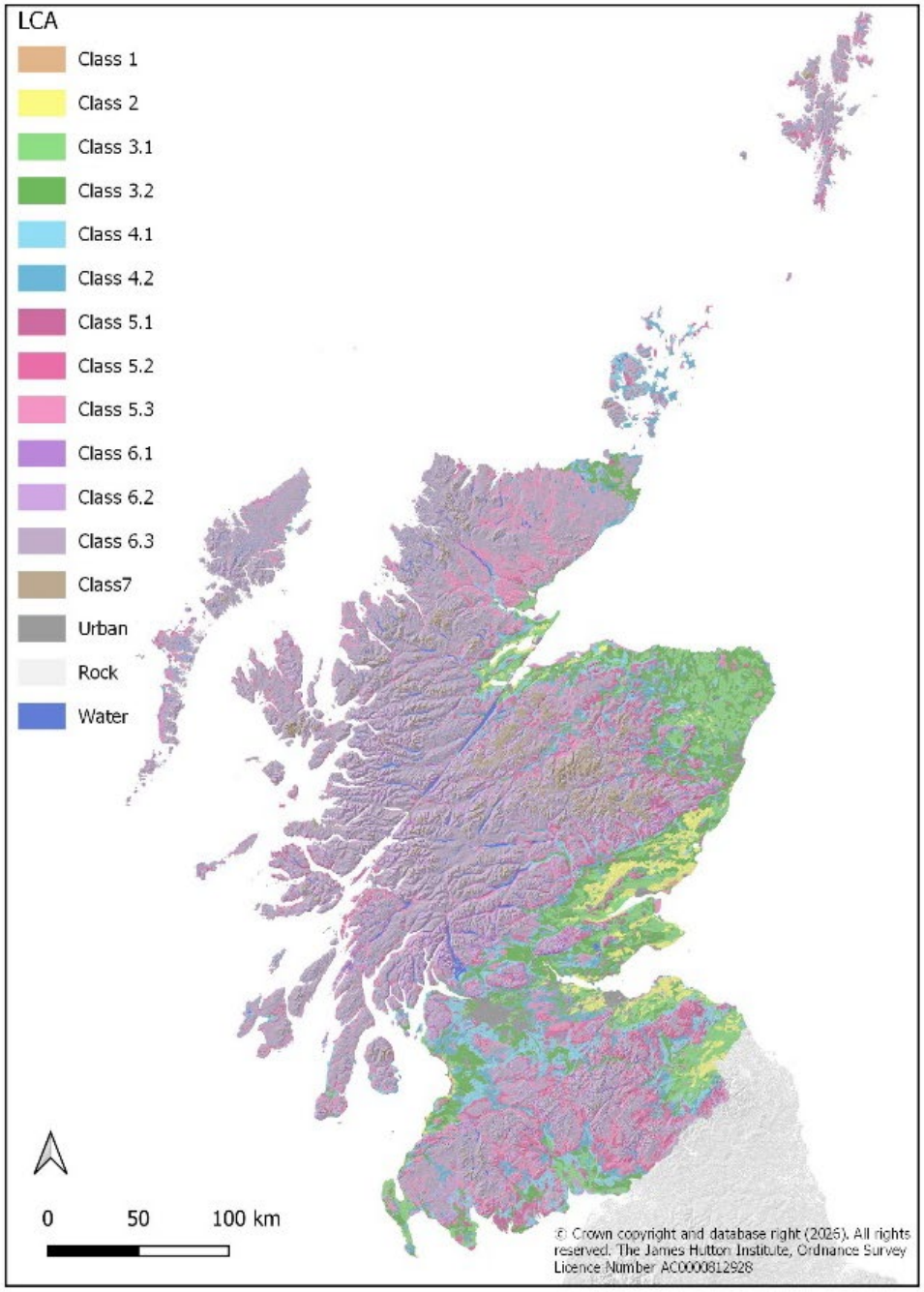
The Scottish LCA was developed in 1982 primarily as a way of systematically assessing the biophysical capability of land to support agriculture by taking account of the interactions between soils, climate and terrain. The National Planning Policy Framework in England[117], Planning Policy Wales[118], and The Strategic Planning Policy Statement for Northern Ireland[119] also offer some protection to productive soils in terms of identifying 'Best and Most Versatile' (BMV) land through the use of the Agricultural Land Classification (ALC) method. A Land Capability for Forestry Assessments also exists; however, forests and woodlands are dealt with separately in NPF4 (See NPF4 Policy 6, Forests, woodlands and trees).

NPF4 policy[5] states "LDPs should protect locally, regionally, nationally and internationally valued soils, including land of lesser quality that is culturally or locally important for primary use" and more specifically NPF4 policy 5b[5] refers to development proposals on prime agricultural land, or land of lesser quality. Nationally, prime land occupies around 6% (or 446,500 ha) of Scotland (from 1:50,000 scale LCA mapping; Soil Survey of Scotland Staff (1984-87)) but it is not equally distributed across local authorities and so the extent to which prime agricultural soils are protected may vary geographically.

[117] https://www.gov.uk/government/publications/national-planning-policy-framework--2 (Accessed May 2026)

[118] https://www.gov.wales/sites/default/files/publications/2024-07/planning-policy-wales-edition-12.pdf (Accessed May 2026)

[119] https://www.infrastructure-ni.gov.uk/publications/strategic-planning-policy-statement-edition-2 (Accessed May 2026)



National scale Land Capability for Agriculture. Soil Survey of Scotland Staff (1981). Land Capability for Agriculture maps of Scotland at a scale of 1:250 000. Macaulay Institute for Soil Research, Aberdeen. 10.5281/zenodo.6322683

LCA Class		LCA Class Description
	1	Land capable of producing a very wide range of crops
	2	Land capable of producing a wide range of crops
	3.1	Land capable of producing consistently high yields of a narrow range of crops and/or moderate yields of a wider range. Short grass leys are common.
	3.2	Land capable of average production though high yields of barley, oats and grass can be obtained. Grass leys are common
	4.1	Land capable of producing a narrow range of crops, primarily grassland with short arable breaks of forage crops and cereal
	4.2	Land capable of producing a narrow range of crops, primarily on grassland with short arable breaks of forage crops
	5.1	Land capable of use as improved grassland. Few problems with pasture establishment and maintenance and potential high yields
	5.2	Land capable of use as improved grassland. Few problems with pasture establishment but may be difficult to maintain
	5.3	Land capable of use as improved grassland. Pasture deteriorates quickly
	6.1	Land capable of use as rough grazing with a high proportion of palatable plants
	6.2	Land capable of use as rough grazing with moderate quality plants
	6.3	Land capable of use as rough grazing with low quality plants
	7	Land of very limited agricultural value
	8	Urban

B9: Technical guidance for managing soils under development

Scotland's Soil Website: Scotland's Soil Website[120] provide several pathways to obtain advice and support for soils in the Scottish planning system and for sustainable soil management within planning and development

Soil, development planning & SEA	Scottish Environment Protection Agency (SEPA) Strategic Environmental Assessment (gives contact details for advice on soils)
Soil, development management and EIA	Scottish Environment Protection Agency (SEPA) Development Management Consultation Thresholds (relating to developments on peat and site waste management, including soils)[121]
	NatureScot Guidance - Development management and the natural heritage[122]
	NatureScot Advising on peatland, carbon-rich soils and priority peatland habitat in development management[123]
	NatureScot & Historic Environment Scotland Environmental Impact Assessment Handbook - version 5 (Appendix 4: Assessment of Impacts on Soils)[6]
	Historic Environment Scotland Environmental Impact Assessment[124]
	Scottish Forestry Environmental Impact Assessments[125]
Other	Department for Environment, Food & Rural Affairs (Defra) (2009) Code of practice for the sustainable use of soils on construction sites (legislation section not relevant to Scotland)[126]
	West Lothian Council Planning Guidance PG - Soil Management & After Use of Soils on Development sites (adopted April 2021)[127]
	Soils in Planning and Construction Taskforce (2022) Building on soil sustainability: Principles for soils in planning and construction[128]

[120] https://soils.environment.gov.scot/resources/planning-and-development/ (Accessed May 2026)

[121] https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.sepa.org.uk%2Fmedia%2Fgzvbn53s%2Fdm-consultation-thresholds-and-standing-advice.docx&wdOrigin=BROWSELINK (Accessed May2026)

[122] https://www.nature.scot/doc/guidance-development-management-and-natural-heritage (Accessed May 2026)

[123] https://www.nature.scot/doc/advising-peatland-habitats-and-carbon-rich-soils-development-management (Accessed May 2026)

[124] https://www.historicenvironment.scot/advice-and-support/planning-and-guidance/environmental-assessment/environmental-impact-assessment/ (Accessed May 2026)

[125] https://www.forestry.gov.scot/forestry-environmental-impact-assessment (Accessed May 2026)

[126] https://www.gov.uk/government/publications/code-of-practice-for-the-sustainable-use-of-soils-on-construction-sites (Accessed May 2026)

[127] https://www.westlothian.gov.uk/media/48547/PG-Planning-Guidance-Soil-Management-After-Use-of-Soils-on-Development-Sites-Adopted-April-2021-/pdf/PG_-_Soil_Management___After_Use_of_Soils_on_Development_Sites_-__Adopted_Version_for_Web.pdf?m=637527818523870000 (Accessed May 2026)

[128] https://www.lancaster.ac.uk/lec/sustainable-soils/files/2022/09/Soils-in-Planning-and-Construction-Sept-22.pdf (Accessed May 2026)

	IEMA (2022) EIA Guidance on Land and Soils (blog with link to request access to guidance)[129,8]
	BSSS (2022) Working with soil guidance note on benefitting from soil management in development and construction[130]
	SNIFFER - Good Practice Guidance (2004) Planning for soil: advice on how the planning system can help to protect and enhance soils[131]
	Definitions of carbon rich soils[132]
	Origins of the Soil Survey of Scotland 50 cm threshold to define a Peat soil[133]
	Scottish Forestry Woodland removal[134]
	Scottish Forestry Felling permission[135]
	SEPA guidance – on-site management of excavated peat[136]

NatureScot:

- Guidance on developments on peatland: peatland survey[137]
- Peat landslide hazard and risk assessments: best practice guide for proposed electricity generation developments[138]
- Floating roads on peat[139]
- EIA handbook – soil Appendix[140]
- Soils of National Conservation Importance in Scotland[141]

[129] https://www.isepglobal.org/resources/blogs/2022/02/17/isep-launch-of-new-eia-guidance-on-land-and-soils-february-2022/ (Accessed May 2026)

[130] https://soils.org.uk/wp-content/uploads/2022/02/WWS3-Benefitting-from-Soil-Management-in-Development-and-Construction-Jan-2022.pdf (Accessed May 2026)

[131] https://verture.org.uk/ (Accessed May 2026)

[132] https://soils.environment.gov.scot/media/haabyors/180319_definitions-of-carbon-rich-soil_agreed-text-for-website.pdf (Accessed May 2026)

[133] https://sefari.scot/sites/default/files/documents/Origin%20of%2050%20cm%20Threshold%20for%20Defining%20Peat%20on%20Soil%20Maps%20of%20Scotland.pdf (Accessed May 2026)

[134] https://www.forestry.gov.scot/publications/control-woodland-removal-policy (Accessed May 2026)

[135] https://www.forestry.gov.scot/apply-fell-trees (Accessed May 2026)

[136] https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fbeta.sepa.scot%2Fmedia%2Fetmkl4ri%2Fwas-g-11-on-site-management-of-excavated-peat.docx&wdOrigin=BROWSELINK (Accessed May 2026)

[137] https://www.gov.scot/publications/peatland-survey-guidance/ (Accessed May 2026)

[138] https://www.gov.scot/publications/peat-landslide-hazard-risk-assessments-best-practice-guide-proposed-electricity/ (Accessed May 2026)

[139] FCE-SNH-Floating-Roads-on-Peat-report.pdf (Accessed My 2026)

[140] https://www.nature.scot/professional-advice/planning-and-development/environmental-assessment/environmental-impact-assessment (Accessed May 2026)

[141] https://www.nature.scot/doc/archive/guidance-soils-national-conservation-importance-scotland (Accessed May 2026)

B10: Other relevant documents

Carbon calculator for wind farms on Scottish peatlands: The Scottish Government carbon calculator is our tool to support the process of determining wind farm developments in Scotland. The tool's purpose is to assess, in a comprehensive and consistent way, the carbon impact of wind farm developments. This is done by comparing the carbon costs of wind farm developments with the carbon savings attributable to the wind farm. The tool and supporting guidance material (e.g. technical guidance[142] for using the carbon calculator) remain the property of the Scottish Government. SEPA and Scottish Renewables have produced guidance on the assessment of peat volumes, the reuse of excavated peat, and the minimisation of waste[143], which was published in February 2014.

Defra Code of Practice for Sustainable Management of Soils in Construction (2011). Defra produced a UK Code of Practice to assist the construction sector to better protect soil resources. This includes advice for carrying out pre-construction planning surveys and incorporating soil resource knowledge into a working strategy (e.g. Site Waste Management Plan or Material Management Plan). It also guides the management of soils during the construction phase through the production of a Soil Resource Plan which outlines areas and soil (topsoil and subsoil) to be stripped, methods to be used, type and management of stockpile creation as well as best practice for soil handling during operations. https://www.gov.uk/government/publications/code-of-practice-for-the-sustainable-use-of-soils-on-construction-sites This document, which dates from 2009, has not been reviewed or updated since. It may not exactly reflect current legislation or controls. It continues to be used to provide relevant advice and has been retained for reference purposes.

Ministry of Agriculture Fisheries and Food (now DEFRA): Produced a Good Practice Guide for Soil Handling[144] in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

Institute of Quarrying (IoQ): The aim of IoQ's 'Good Practice Guide for Handling Soils in Mineral Workings[145] (2000)' is designed specifically to help the mineral industry and its contractors achieve a good standard of restoration when using various combinations of earth-moving machinery for soil stripping, storage and replacement. The guidance entails specific advice relating to soil stripping, creating bunds and mounds, soil replacement and reinstatement and soil decompaction.

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[142] https://www.gov.scot/publications/carbon-calculator-technical-guidance/ (accessed May 2026)

[143] https://www.gov.scot/publications/assessment-of-peat-volumes-reuse-of-excavated-peat-and-minimisation-of-waste-guidance/ (Accessed May 2026)

[144] https://gat04-live-1517c8a4486c41609369c68f30c8-aa81074.divio-media.org/filer_public/35/98/359889e9-848f-442a-9569-52f5332e8787/12221.pdf (Accessed May 2026)

[145] https://www.quarrying.org/hubfs/Soils%20Guidance/IQ%20Soil%20Guidance%20full%20document%20including%20all%20practitioner%20advice%20updated%20May%202022.pdf (accessed May 2026)

British Soil Science Society: In 2022, BSSS published the **'**Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction'[130] written for development planning and control professionals, site owners and developers to help promote the protection of soils and the important functions they support within the planning system and the development of individual sites

Institute of Sustainability and Environmental Professionals (ISEP)- Formally IEMA (2022): A New Perspective on Land and Soil in Environmental Impact Assessment[8] provides guidelines to help practitioners understand and record the full environmental implications of development on land and soil, embedding sustainable soil management throughout EIA

'**Soils and Stones' Project and the SILOtoSOIL Tool:** The Society for the Environment (SocEnv) have published ten basic principles of good soils and stones management[146] to provide a common framework to underpin a circular, sustainable economy. In addition, SocEnv collaborated with Middle Land Events (MidLE) to develop The SILOtoSOIL Tool[147] to highlight the wealth of existing soil related expertise, guidance, and publications available across different disciplines and locations and encourage knowledge- sharing and promote more efficient collaboration. The project team published an initial Soils and Soils report (2021)[148] and fed into the recommendations of the 2023 Environment, Food and Rural Affairs Committee (EFRA) Soil Health Inquiry[149].

Soils in Planning & Construction Task Force: The Soil Task Force[150] is a cross-sector initiative established in 2021 that aims to raise awareness of the importance of soil in developments, set out more ambitious principles for incorporating soil sustainability in planning and construction. The team produced 'Building on soil sustainability: Principles for soils in planning[128]' report and more recently a Local Soils Model[151]. The model policy is intended to be adaptable for use by any local planning authority and is structured to reflect the diverse considerations required for effective soil management.

[146] https://socenv.org.uk/wp-content/uploads/2023/03/FINAL-Ten-Soils-Stones-Principles.pdf (Accessed May 2026)

[147] https://socenv.org.uk/silo-to-soil/ (Accessed May 2026)

[148] https://socenv.org.uk/resource/socenv-soils-and-stones-report/ (Accessed May 2026)

[149] https://socenv.org.uk/socenv-evidence-featured-efra-soil-health-inquiry-report/ (Accessed May 2026)

[150] https://www.soilstaskforce.com/about (Accessed May 2026)

[151] https://786141fa-0932-49ad-a74b-e7239fa0aac4.filesusr.com/ugd/7be451_6178ad975e1d44d3b58b3d5fefcee438.pdf (Accessed May 2026)

Appendix C – Supplementary information for Theme 2 Physical health of Scottish soils

C1: Evidence from the 'Physical Degradation of Soils' Stakeholder Workshop

A workshop was held in Edinburgh on Thursday 16th October 2025with invited soil scientists, advisors, land practitioners, regulators, conservationists, academics and policy makers. The following tables set out the evidence gathered from the event.

Group discussions were conducted to

- Identify common causes & impacts of physical soil degradation across land uses
- Outline regulation and guidance available to support the prevention and/or restore soil physical health
- Explore potential interventions which could be applied across different land uses to protect and restore soils while co-delivering to multiple policy objectives
- Highlight existing networks that can support the implementation of interventions identified

C1(a): Common causes of physical soil degradation across land uses / sectors highlighted within the workshop

	Forestry	**Agriculture**	**Built environment**	**Peat/organic soils**
Machinery use	Machinery: (size & frequency) causes compaction, especially on wet soils			
Grazing		Livestock pressure e.g. grazing, especially in winter can compact and erode soil.		Grazing pressures
Drainage	Historical drainage and windthrow cause erosion.	Drainage issues with artificial systems disrupting natural hydrology.		Historical and ongoing drainage lowering of water tables.
Significant disturbance	e.g. Clear felling	e.g. Cultivation	e.g. Infrastructure developments (roads, pipelines, urban sprawl)	e.g. Infrastructure developments (windfarms, battery plants).
General management	Poor management - Commercial focus, wrong species/location, monocultures, peatland planting.	Poor timing e.g. conducting work when soil is vulnerable.	Poor soil management in construction (sealing, compaction, soil treated as waste)	Peat removed for fuel or horticulture. Restoration activities can be temporarily disruptive.

	Forestry	**Agriculture**	**Built environment**	**Peat/organic soils**
Chemical/ contamination		Chemical use - pesticides and fertilizers degrade soil health	Contamination (from industry, turf, microplastics.)	
Landscape/ historical	Challenges balancing commercial and conservation priorities, lack of rooted diversity.	Landscape changes e.g. loss of trees, hedgerows and floodplains.	Restoration challenges: Mining and landfill activities often leave long-term impacts	Vegetation change, forestry regrowth and encroachment all change soil dynamics.
Guidance & Support	Poor management, inconsistent guidance application, fragmented decision-making.	Lack of knowledge/support: Complexity in advice, poor decisions on crop-soil matches.	No clear national protection policy for soils. Lack of guidance, soil valued differently across local authorities	
Climate - related	Disturbance from fire and disease (directly and/or indirectly)		Floods, wildfires, and poor weather work worsen degradation.	Climate change alters water balance, increases oxidation and erosion. Wildfires/muirburn impacts on soil functions

C1(b): What exists to protect & restore the physical integrity of soils?

	Forestry	Agriculture	Built Environment	Peat/organic
Guidance & technical support	Integrate soil with water and peat policies; be more ambitious beyond damage limitation.	Technical support (SAC), Value Your Soils, FAS advice, RPNS, intercropping, soil monitoring.	Guidance clarity: Mandatory codes (e.g. construction soil use) better followed than voluntary ones.	Knowledge & guidance: Practical tools for planners, cross-agency coordination (NatureScot, Scottish Forestry).
Policy / legislation/ Regulation / strategy	Forest strategies, National frameworks: Scottish Biodiversity Strategy (SBS) and delivery plans, River Basin Management Plans (RBMP), Wild Salmon Strategy.	Soil-conscious regulations: GAECs (esp. for compaction/erosion), NVZ rules, EASR GBRs, SEPA RBMP oversight. Outcome focus: Long-term goals (e.g. 5-year resilience targets) & integrate into biodiversity/climate strategies (e.g. emissions reduction and adaptation goals.)	Planning integration: Embed soils in NPF4, BNG, greenbelt strategies. Improve policy and enforcement: National policy gaps remain; strong enforcement is key (e.g. via planning or EIA conditions). Cross-sector coordination: Local planning units sharing knowledge (e.g. West Lothian), alignment of water, soil, and greenspace goals.	Funding mechanisms: Peatland Action, agri-support for ditch blocking, Scope 3 incentives. Legal & policy drivers: Legally binding climate targets, inclusion in NPF4 and EIA processes. Monitoring & mapping: Identify peat and organic soils via EIA and national mapping. Regulations: Muirburn code/licensing, UK Forest Standard (peat depth), CAR for water abstraction, Nature Conservation Act.
Practical applications	Low-impact practices: Use brash mats at harvest, avoid blanket felling, maintain cover. Species selection: Match trees to rooting depth and soil type. Restore deep peat sites: Convert forest back to bog.	Soil-building practices: Living roots, green manure, low ground pressure tires, reduce traffic, improve structure. Minimise bare soil: Use cover crops, herbal leys, and erosion controls.	On-site protection: Protect 'valuable' soils; soil reuse planning (before digging). Technical tools: CEMPs, industry codes (e.g. CIRIA, DEFRA), geotextiles.	Restoration techniques: Drain blocking, re-profiling, wetting, de-stocking, deer control. Land management: Right species, low-impact planting timing, compliance (e.g. GAEC 6), reduce grazing pressure.

	Forestry	**Agriculture**	**Built Environment**	**Peat/organic**
Monitor, data	Site-sensitive planning: Use LIDAR/soil maps to guide machinery and operations.			
Support	Forest grant scheme		Public education: Shift perception of soil from "waste" to "resource".	

C1(c): Opportunities to support/improve soil protection / restoration

	Forestry	Agriculture	Built environment	Peat/organic soils
Policy, regulation, incentives:	Strengthen and unify fragmented guidance and standards (e.g. soil protection, forestry codes) Ensure compliance through grant conditions and EIA use Improve guidance on cultivation, especially for upland woodland Consider EU soil monitoring law applicability	Build soil health into whole farm plans, agri-environment schemes and climate indicators Update GAECs and PEPFAA codes to target soil protection more explicitly Link nutrient planning with soil physical condition Value soil's multifaceted functions and embed soil in catchment/ landscape-scale planning	Strengthen planning policy (e.g. NPF4) to include soils explicitly Separate soil and LCA assessments Better enforcement of EIA conditions and construction consents	Embed organic soils protection in NPF4 and upcoming Peatland Strategy Strengthen SEPA and EIA guidance (e.g. PHLRA, drainage monitoring) Consider soils in relation to the Circular Economy Bill Consider EU soil monitoring law applicability
Planning & Practice	Promote "right tree, right place" decisions tied to soil health and climate resilience Encourage long-term woodland planning with soil as a key factor Include soil health in impact assessments at planting and over time Improve drainage management, avoid tree felling near water, and restore forests to bogs	Support deeper rooting, cover crops, herbal leys, and green manure use	Embed/encourage mitigation hierarchy in relation to soils before construction begins Reduce 'waste soil' through circular economy thinking (Recognize the scale of soil loss to landfill – potential "easy win") Include soil in maintenance plans and biodiversity strategies (e.g. BNG) Ensure policies are followed by resources for implementation and enforcement	Promote peatland restoration (e.g. ditch blocking, re-profiling, rewetting) Align with crofting, farming, forestry – avoid conflicts across land uses Manage grazing and deer pressure to reduce degradation

	Forestry	Agriculture	Built environment	Peat/organic soils
KE, networks & mindset	Increase contractor awareness and buy-in Support site-level coordination and small contractor models for better control Consolidate ownership where possible to improve consistency in best practice	Expand farmer clusters, agronomy groups, and peer-to-peer learning Improve language and communication to reach wider farmer audiences Encourage industry-driven standards to promote soil health Promote regenerative and no-till practices	Shift mindset: soil is not just "muck to get rid of"	Link peatland action with biodiversity, water quality, and climate resilience Recognize cultural and natural heritage value of organic soils
Support, upskilling, funding & incentives:	Expand woodland carbon code to include soil health Attract private funding (e.g. LENS) for mixed land use and agroforestry Invest in education/training modules on soils in forestry	Funding to support the withdrawal of marginal fields from production in order to protect soils	Establish apprenticeships and practical guidance for soil management Support local authorities with expertise and shared learning platforms Align soil science and soil mechanics for better industry uptake	Use Peatland and Ecosystem Restoration Codes to attract private finance Support for multifunctional land use (e.g. peatland and sheep farming)
Research, data, knowledge, innovation	Utilize research (e.g. CREW 2025, Forest Research ECOS) to inform soil-focused decision	Use LIDAR and EO to identify erosion hotspots Develop big data and machine learning tools to understand spatial soil variation Create a central soil data hub for research and farm planning	Develop national soil map and degradation monitoring framework	Translate peat maps for decision-makers
			Link carbon calculators and biodiversity metrics to soil outcomes	Improve guidance for planners on peat protection
				Foster respectful, context-sensitive communication among stakeholders

C1(d): What networks / frameworks exist to help implementation?

	Forestry	**Agriculture**	**Built Environment**	**Peatland/organic**
Policy, guidance and supporting services	UK Forest Standards (UKFS) Scottish Forestry Operational Guidance Forestry Grant Scheme (FGS) Land Use Strategy (LUS) Peatland Action	EU Soil Monitoring Law (influential) Land Use Strategy, Natural Environment Bill	Local planning excellence (e.g. West Lothian Council) Circular Economy Route Map (addresses soil waste) Brownfield registry	Peatland Action (NatureScot, Scottish Forestry) Clear compliance rules (e.g. UKFS 10cm peat threshold)
Research and supporting organisations	Forest Research Forestry Commission portal (planning tool)	SEFARI, James Hutton Institute (JHI), FAS, NatureScot QMS, AHDB, SAOS Farmer-to-farmer networks, farm clusters (NFU/LENS), agronomy groups Regional Land Use Partnerships (RLUPs) NFUS, NFFN, Pasture for Life, Soil Association, Monitor Farms	Technical and Professional Bodies (BSSS, CIRIA, BRE, CIEEM, IEMA, IES, ISSMG) British Geological Survey, Institute of Civil Engineers International Geosynthetics Society Proposed Scotland-wide soil map and monitoring system	Peatland Code / Ecosystem Restoration Code EIA requirements Crofting communities (common grazing) Whisky industry RSPB, Soil Association, IUCN, UNESCO
Enforcement, certification & private investment	Forest Certification (e.g. FSC) Confor (industry voice) Institute of Chartered Foresters (ICF) – knowledge exchange Improved enforcement and monitoring of EIAs SEPA Woodland Carbon Code	Supermarkets (RSPCA standards), LENS initiatives Interest from farmers – growing awareness of soil's role Soil carbon and biodiversity credits Climate-smart advisors	Local Authorities and Councils NHS (greenspace links to health) Building developers/contractors Scottish Golf Environmental Group SEPA	Embedded value in natural and historic landscapes

C2: Regulation and guidance relevant to soil physical degradation identified at the stakeholder engagement workshop

Summary of existing regulations and guidance identified in the workshop mapped to where they can provide support and advice for protecting soils from compaction and physical degradation across Peatland habitats (Pe) , Agriculture (A) and Forestry (F) land uses and Planning (Pl) *This only reflects the workshop discussion and does not represent a comprehensive list of Scottish regulation and guidance.*

Note: This is not an exhaustive list. This table shows regulations and guidance identified by stakeholders during the workshop. Other guidance is available e.g. Farm Advisory Service advice and guidance on compaction at Soil Structure & Compaction Publications | Helping farmers in Scotland[152], tyre selection management guidance and Valuing your soils - Farming and Water Scotland[153] for compaction and mitigation measures in a Scottish context and Enhance Greening Environmental Focus areas options - Ecological Focus Areas[154].

	Options for action	Support and Guidance specific for or relevant to Scotland	A	F	Pl	Pe
Heavy loads	Avoid operating heavy machinery on wet ground (weight & timing) and use low pressure machinery (e.g. flotation tyres), especially on wet or sensitive soils. Controlled traffic/confine machinery use to designated routes	Environmental Authorisations (Scotland) Regulations 2018: General binding rules – Noe integrated into the Environmental Authorisations (Scotland) Regulations (2018) [from 1 Nov 2025]	x			
		The Common Agricultural Policy (Cross-Compliance) (Scotland) Regulations 2014[155] (including GAECs)	x			x
		AHDB Soil Compaction from Machinery (Guidance)[156]	x			
		PEPFAA code: buffers for operating machinery near watercourses.	x			

[152] https://www.fas.scot/crops-soils/soils/soil-structure-compaction-publications/ (Accessed May 2026)

[153] https://www.farmingandwaterscotland.org/soil-nutrients/valuing-your-soils/ (Accessed May 2026)

[154] https://www.ruralpayments.org/topics/all-schemes/basic-payment-scheme/basic-payment-scheme-full-guidance/greening---bps/greening-guidance-2026/efa-ecological-focus-areas/ (Accessed May 2026)

[155] https://www.legislation.gov.uk/ssi/2014/325/contents (Accessed May 2026)

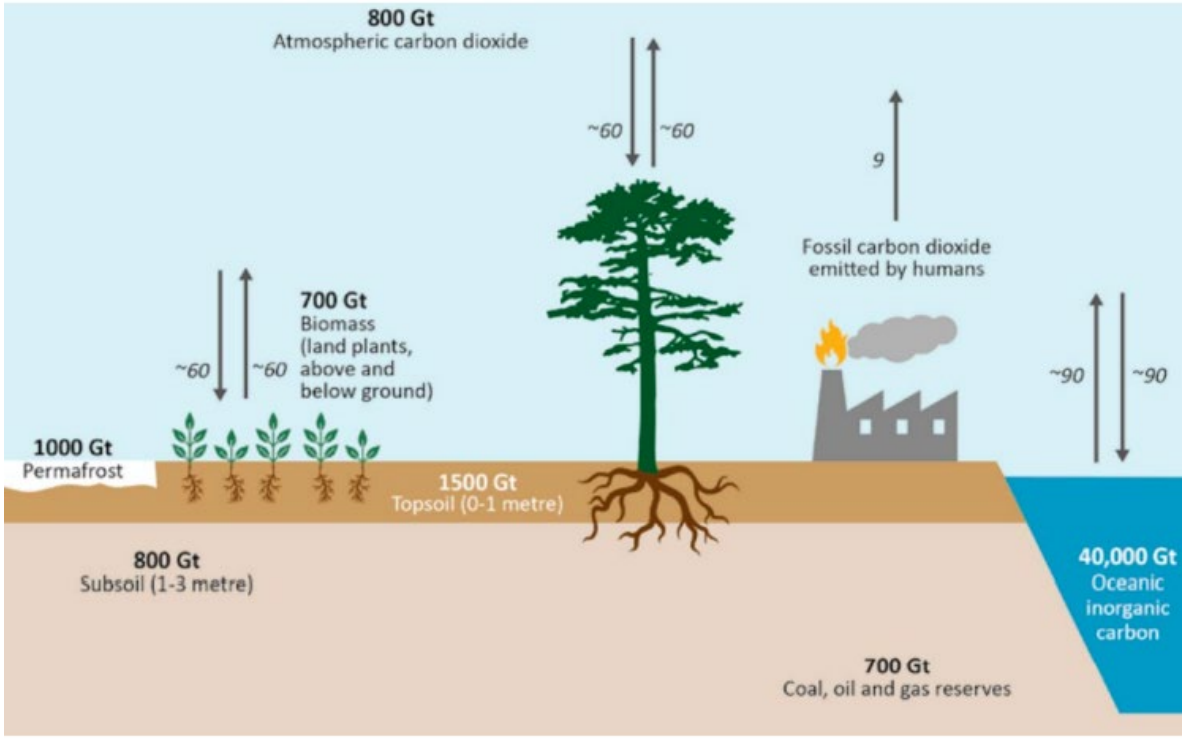
[156] https://ahdb.org.uk/knowledge-library/soil-compaction-from-machinery#:~:text=Reduce%20machine%20size%20and%20total%20axle%20loads;,deep%2Dseated%20compaction%2C%20even%20with%20large%20low%2Dpressure%20tyres (Accessed May 2026)

	Options for action	Support and Guidance specific for or relevant to Scotland	A	F	Pl	Pe
		Defra Code of Practice for Sustainable Use of Soils in Construction			x	
		Institute of Quarrying 'Good Practice Guide for Handling Soils in Mineral Workings'			x	x
		Ministry of Agriculture Fisheries and Food Good Practice Guide for Soil Handling			x	x
		UKFS Soil Guideline 6 - Minimise compaction, rutting and erosion during forest operations	x			x
	Manage grazing pressure	GAEC 5: Minimum land management reflecting site specific conditions to limit erosion Minimum soil cover	x			
Disturbance and exposure	Limit bare/exposed soil	GAEC 6: Maintenance of soil organic matter or do you mean GAEC 5	x			
		Agricultural reform list of measures – cover crop (winter)	x			
		Buffer strips (tree/veg), hedges and grass to prevent soil runoff (GAEC, FWS, PEPFAA, EASR)	x	x		
		EASR Guidance: Construction works and silt / pollution mitigation			x	
	Reduce/manage cultivation	Agricultural reform list of measures	x			
		Farming Water Scotland - Know the rules (mind the gap)	x			
		Scottish Biodiversity Strategy to 2045	x	x	x	x
	Loss of hedgerows & trees	GAEC 7: Retention of landscape features				
	Reduce/manage impacts of felling	Forestry and Water Scotland - Know the rules				
	Use brash mats	UKFS Soil Guideline 8		x		
	Schedule construction to minimise length of soil exposure & stockpiles management	Guidance in the DEFRA Construction Code of Practice for the Sustainable Use of Soils outlines detailed procedures for stripping, stockpiling, and handling soil.			x	
	Use of geotextiles	NatureScot's Good practice during wind farm construction			x	x
		EASR Guidance: Construction works and silt / pollution mitigation	x	x	x	x

Appendix D – Supplementary information for Theme 4 - Soils in the private sector

D1: The global carbon cycle

The carbon cycle from The British Soil Science Society – Science Note on Soil Carbon. Carbon stocks and flows on land and in the oceans (adapted from Jenkinson, 2010). The numbers in bold are stocks in Gigatonnes (Gt) C: those in italics are flows in Gt C per year. Topsoil and subsoil stocks exclude peatlands.



D2: Soils in the Taskforce for Nature-Related Financial Disclosure (TNFD) sector specific guidance

(a) Materiality ratings of soil-specific ecosystem services each sector typically depends on, as outlined in TNFD sector guidance[81]. Dependency is noted as very high (VH, in red), high (H, in red), Medium (M, in orange), Low (L, in blue), very low (VL, in blue).

Sector	Activity	Regulating and maintenance services		ENCORE Source
		Soil and sediment retention	Soil quality regulation	
Beverage	Growing of cereals (except rice), leguminous crops and oil seeds	VH	VH	2024
	Growing of sugar cane	VH	VH	2024
	Other land transport	L	-	2024
	Distilling, rectifying and blending of spirits	L	-	2024
	Manufacture of malt liquors and malt	L	-	2024
	Manufacture of wines	L	-	2024
	Manufacture of soft drinks; production of mineral waters and other bottled waters	L	-	2024
	Beverage serving activities	L	-	2024
Metals and mining	Mining and quarrying n.e.c.	M	-	2024
	Mining of hard coal	M	-	2024
	Mining of iron ores	M	-	2024
	Mining of lignite	M	-	2024
	Mining of nonferrous metal ores	M	-	2024
	Support activities for other mining and quarrying	M	-	2024
Mar ine tran	Building of ships and boats	M	-	2024

Sector	Activity	Regulating and maintenance services		ENCORE Source
		Soil and sediment retention	Soil quality regulation	
	Warehousing and storage	M	-	2024
	Sea and coastal transportation	L	-	2024
	Cargo handling	L	-	2024
	Service activities incidental to water transportation	L	-	2024
	Onward transport (inland water transport)	M	-	2024
Apparel, accessories and footwear	Raising of sheep and goats	VH	H	2024
	Raising of cattle and buffaloes	VH	H	2024
	Growing of fibre crops	VH	VH	2024
	Other land transport	L	-	2024
	Manufacture of other textiles	L	-	2024
	Manufacture of manmade fibres	L	-	2024
	Extraction of crude petroleum	L	-	2024
	Manufacture of refined petroleum products	M	-	2024
	Manufacture of other chemical products	M	-	2024
	Manufacture of basic chemicals	M	-	2024
Aquaculture	Aquaculture direct operations	VH	M	2024
	Manufacture of prepared animal feeds	L	-	2024
	Fishing	VH	M	2024

Sector	Activity	Regulating and maintenance services		ENCORE Source
		Soil and sediment retention	Soil quality regulation	
	Processing and preserving of fish, crustaceans and molluscs	L	-	2024
Biotechnology and pharmaceuticals	Inorganic & organic feedstock	VH	H	2018-23
	Energy supply	L	-	2018-23
	Manufacturing & production	L	-	2018-23
	Packaging	L	-	2018-23
	Distribution	M	-	2018-23
	Manufacture of basic chemicals	M	-	2024
	Silviculture and other forestry activities	VH	VH	2024
	Growing of cereals (except rice), leguminous crops and oil seeds	VH	VH	2024
	Manufacture of refined petroleum products	M	-	2024
	Fossil fuels energy production	M	-	2024
	Research and experimental development on natural sciences and engineering	VL	-	2024
	Manufacture of pharmaceuticals, medicinal chemical and botanical products	M	-	2024
Chemicals	Inorganic and organic feedstock and raw materials: Large-scale forestry	VH	H	2018-23
	Inorganic and organic feedstock and raw materials: Large-scale irrigated arable crops	VH	H	2018-23
	Energy supply: Oil and gas refining	L	-	2018-23
	Energy supply: Nuclear and thermal power stations	L	-	2018-23
	Research and experimental development on natural sciences and engineering	L	-	2018-23

Sector	Activity	Regulating and maintenance services		ENCORE Source
		Soil and sediment retention	Soil quality regulation	
	Synthetic fertiliser production	VL	-	2018-23
	Catalytic cracking, fractional distillation and crystallisation	L	-	2018-23
	Cryogenic air separation	L	-	2018-23
	Polymerisation	L	-	2018-23
	Electric/ nuclear power transmission and distribution	H	-	2018-23
	Solids processing	L	-	2018-23
	Distribution	M	-	2018-23
	Manufacture of basic chemicals	M	-	2024
	Manufacture of other chemical products	M	-	2024
	Manufacture of fertilizers and nitrogen compounds	M	-	2024
	Silviculture and other forestry activities	VH	VH	2024
	Growing of cereals (except rice), leguminous crops and oil seeds	VH	VH	2024
	Manufacture of refined petroleum products	M	-	2024
	Fossil fuels energy production	M	-	2024
	Research and experimental development on natural sciences and engineering	VL	-	2024
Construction materials	Quarrying of stone, sand and clay	H	-	2024
	Support activities for other mining and quarrying	M	-	2024
	Installation of industrial machinery and equipment	M	-	2024

Sector	Activity	Regulating and maintenance services		ENCORE Source
		Soil and sediment retention	Soil quality regulation	
	Manufacture of non-metallic mineral products n.e.c.	L	-	2024
	Manufacture of other chemical products	M	-	2024
Electric utilities and power generators	Fossil fuels thermal power stations	M	-	2024
	Nuclear thermal power stations	H	-	2024
	Hydropower	VL	-	2024
	Wind	M	-	2024
	Solar	M	-	2024
	Biomass	L	-	2024
	Geothermal	H	-	2024
	Power transmission and distribution	L	-	2024
Engineering, construction and real estate	Steam and air conditioning supply	VL	-	2024
	Building completion and finishing	M	-	2024
	Construction of buildings	H	-	2024
	Construction of other civil engineering projects	H	-	2024
	Construction of roads and railways	H	-	2024
	Construction of utility projects	H	-	2024
	Demolition and site preparation	M	-	2024
	Electrical, plumbing and other construction installation activities	M	-	2024

Sector	Activity	Regulating and maintenance services		ENCORE Source
		Soil and sediment retention	Soil quality regulation	
	Other specialised construction activities	M	-	2024
	Real estate activities on a fee or contract basis	M	-	2024
	Real estate activities with own or leased property	M	-	2024
	Architectural and engineering activities and related technical consultancy	M	-	2024
	Specialised design activities	VL	-	2024
Fishing	Fishing	VH	M	2024
	Processing and preserving of fish, crustaceans and molluscs	L	-	2024
Food and agriculture	Agricultural products	VH	-	2018-23
	Livestock (beef and dairy)	H	-	2018-23
	Food processing	VL	-	2018-23
	Growing of cereals (except rice), leguminous crops and oil seeds	VH	VH	2024
	Raising of cattle and buffaloes	VH	H	2024
	Manufacture of other food products	L	-	2024
	Other land transport	L	-	2024
	Retail sale of food, beverages and tobacco in specialized stores	M	-	2024
	Restaurants and mobile food service activities	L	-	2024
	Forest production	-	H	2018-23
	Silviculture and other forestry activities	VH	VH	2024

Sector	Activity	Regulating and maintenance services		ENCORE Source
		Soil and sediment retention	Soil quality regulation	
Forestry and paper	Support services to forestry	M	-	2024
	Sawmilling and planing of wood	L	-	2024
	Manufacture of furniture	L	-	2024
	Manufacture of paper and paper products	L	-	2024
	Other land transport	L	-	2024
Oil and gas	Extraction of crude petroleum	L	-	2024
	Extraction of natural gas	L	-	2024
	Support activities for petroleum and natural gas extraction	M	-	2024
	Manufacture of refined petroleum products	M	-	2024
	Manufacture of gas; distribution of gaseous fuels through mains	L	-	2024
Water utilities and services	Construction of utility projects	H	-	2024
	Wholesale of machinery, equipment and supplies	L	-	2024
	Water collection, treatment and supply	M	-	2024
	Sewerage	VL	-	2024
	Materials recovery	VL	-	2024

D3: Soil sector guidance TNFD Description

Sector	Description of potential impact/dependency drivers adapted from TNFD Sector guidance
Beverage	Beverages rely on raw ingredients from agricultural practices. Crop growth depends on high quality soil and access to clean water in the appropriate quantity at the appropriate time. Poorly targeted use of pesticides and fertiliser can contaminate and acidify the soil and lead to the contamination and eutrophication of local water bodies.
Metals and mining	Leak or spillage of fuel, oil or drilling fluids can occur during exploration drilling leading to soil contamination. Spills to soil can adversely affect soil health (particularly the microbial communities) and in turn the regulation services soils provide. Soil disturbance can occur as a consequence of land clearing (e.g. for open cut mining, underground mine portals, aces routes), land excavation (e.g. drilling and blasting) to recover minerals. These activities have adverse effects on soil health and soil and sediment retention
Marine transportation and cruise lines	Development of cruise line private destination hotels, beach resorts, water parks or use of local infrastructure managed via contractual relationships can contribute to land conversion through the siting and design of resorts, development of marinas and artificial lakes etc. Dredging is linked to conversion of benthic habitats and coral reefs.
Apparel, accessories and footwear	Natural fibre and livestock farming for animal-based fibre production can cause changes in land use and drive land degradation by increasing demand for specific crops and accelerating deforestation. Soils can become contaminated by chemicals and dyes used in the textile manufacturing process. Microfibres can infiltrate soil layers through various pathways. Moreover, packaging waste that is dropped as litter or discarded in landfill sites can degrade and lead to microfibres leaking into soil.
Aquaculture	Wetlands provide water for aquaculture and habitats for pond fisheries. There are likely more risks posed to sediments than soils. However, vegetated wetlands provide important ecosystem services and are sources of biodiversity at species, genetic and ecosystem levels. They play a vital role in climate change adaptation and mitigation, such as stabilising soil erosion, reducing storm surges, diminishing effects of high winds and filtering run-off.
Biotechnology and pharmaceuticals	Soil quality regulation is essential to ensure the sustainable production of botanical raw materials used in drug manufacturing. Soil and sediment retention prevents soil erosion and maintain land fertility, which is crucial for consistent crop yield and quality. Pharmaceuticals designed to be slowly degradable or even non-degradable to resist chemical degradation during passage through a human or animal body present a special risk when they enter, persist or disseminate in the environment, for example they can cause antimicrobial resistance.

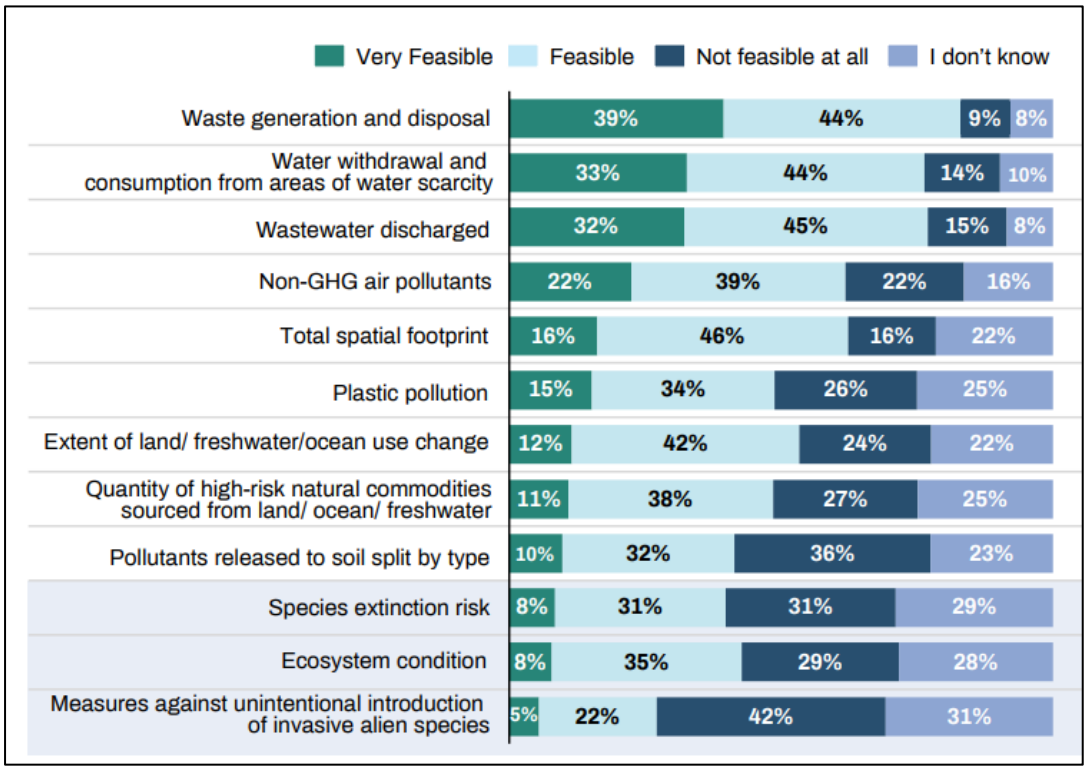
Sector	Description of potential impact/dependency drivers adapted from TNFD Sector guidance
Chemicals	Mining and crop growing practices may cause soil and water pollution and disturb the hydrological balance. Replacing non-renewable resources with renewable feedstock such as natural biomass-based resources including plant-derived chemical products, food waste and forestry residues could enhance waste recycling and reuse, mitigating soil and water pollution.
Construction materials	Soils are disturbed by the extraction, management and rehabilitation or reclamation phases of quarrying for materials. These changes can have knock-on effects on ecosystem services, including cultural services.
Electric utilities and power generators	Electric utilities and power generators sector organisations are highly dependent on several ecosystem services of regulation and maintenance, including mitigation of natural hazards, such as floods and storm surges, erosion control, and soil and slope stabilisation. The functionality of power generation facilities might depend on the ecosystem service of soil and sediment retention, predominantly provided by vegetation and other environmental assets. Through the soil and sediment retention, the impacts of landslides and erosion are mitigated. The operational integrity of transmission and distribution infrastructure might depend on the ecosystem service of soil and sediment retention, predominantly provided by different types of vegetation and other environmental assets. Through the soil and sediment retention, the impacts and damages of landslides and erosion are mitigated.
Engineering, construction and real estate	Construction leads to the creation of sealed surfaces which can disrupt water flow regulation and flood mitigation, while lack of soil permeability can affect water resources as aquifers are not recharged. Water and soil pollutants from construction (Chemical spills and accumulation of waste) changing the chemical make-up of the habitat, harming local species populations and undermining the provision of ecosystem services to local communities, such as soil quality maintenance and water purification. Urban growth leads to congestion, contributing to air pollution, and increased generation of waste, which if poorly managed, can pollute the air, water and soil.
Fishing	Pollution removal: soil pollutants - Avoid using flags of convenience to bypass tighter decommissioning and recycling requirements. Consider the decommissioning plan for the fishing fleet and how it translates into company financial provisions. Put measures in place to avoid beaching or to ensure that it is undertaken in a way that minimises impacts on environmental assets and ecosystem services. List vessels on industry-specific lists, e.g. for tuna fisheries, the ProActive Vessel Register (PVR) and Vessels in Other Sustainability Initiatives (VOSI).

Sector	Description of potential impact/dependency drivers adapted from TNFD Sector guidance
Food and agriculture	Land clearance, including for cultivation and land clearance for livestock grazing/potential overgrazing. Land management responsible practices: no-tillage, set aside preservation areas, crop rotation/integrated farming/others. Application of mineral/ chemical fertiliser. Use of antibiotics in livestock production. Application of organic fertiliser including livestock waste. Application of pesticides (introducing pollutants). Wastewater discharge (e.g. from livestock watering and cleaning, discharge from food processing facilities, from restaurants). Waste generation and disposal (including food spoilage during transportation and transport, food packaging processes, end of life food disposal). Water withdrawal for irrigation, livestock watering, for food processing and cleaning (impacts soil quality)
Forestry and paper	The availability of direct physical inputs (e.g. high-quality soil and water supply, resilience against pests and diseases), extending beyond current land-use borders, and their availability in the medium and long term. Regulating and maintenance services. To capture the impacts of both direct activities and the knock-on effects of business activities, organisations should consider evaluating potential soil and water pollution (and any other sources of pollution) at the landscape level. Organisations should compare changes in soil quality to protected or otherwise intact forest areas, or a similar classification. Soil and water quality are also aspects of ecosystem integrity that are of particular relevance to the sector and should be assessed. Soil pollutants impact soil quality (e.g. Fertilisers and pesticides, chemicals, wastewater discharge)
Oil and gas	Effective soil and sediment retention reduces the erosion of soil and the risk of landslides, which can support transportation infrastructures via pipelines of oil and gas. Spills to the environment and critical incidents can have significant negative repercussions for workers, local communities, the environment and the assets of organisations. These incidents extend beyond fatalities and injuries, often leading to the contamination of air, soil and water. Storage or leaks of hazardous materials can directly contribute to soil pollution. Upstream, mining activities can contribute to dust clouds and mineral deposition. Cleared land leads to increased susceptibility to soil erosion. Upstream, stockpiles and rock dumps can also contribute to erosion. Soil may become unsuitable for native vegetation due to the pollution. Waste products can introduce contaminants into soil, surface water, groundwater and seawater. This can alter the soil and water chemical balances and geomorphological environment structure. Vehicles, equipment and plants can all carry invasive species, as can reclamation programmes that import contaminated soils. Operational and business interruptions caused by landslides as a result of declining soil stability that may damage infrastructure.

Sector	Description of potential impact/dependency drivers adapted from TNFD Sector guidance
Water utilities and services	Healthy soils form a key component of the hydrological cycle and are critical to sustaining the sector as they store, accept, transmit and purify water. Stable soils also lower risks to an organisation's infrastructure from, for example, landslides. Flood mitigation, rainfall pattern regulation and soil and sediment retention: Ecosystem services protect desalination infrastructure from damage and interruption to operations from extreme weather events and natural hazards, such as heavy rainfall, flooding and/or landslides. Water utility organisations may need to consider their dependence on water supply, global climate regulation, air filtration, biological control, soil and sediment retention, noise attenuation and mediation of sensory impacts (other than noise) services for wastewater treatment and discharge activities. Emissions of toxic and nutrient soil and water pollutants. Nutrients in the wastewater can lead to eutrophication and consequently impact aquatic species populations and clean water availability for other users. Release of bacteria and industrial byproducts (e.g. pharmaceutical, cosmetic and chemical, such as PFAS) can further affect animal and human health.

D4: Reporting soil parameters in TNFD

Feasibility of reporting TNFD metrics outlined in *TNFD 2025 Progress Report*[78] (From the TNFD report preparer perspective, which of the following TNFD disclosure metrics did you find feasible to report



Appendix E Supplementary information for Theme 5 - Soil monitoring and metrics

E1: Considerations for soil monitoring in Scotland

There are different types of data that can be combined to define a soil baseline and monitor change. These include:

- Statistically robust national or regional data that can be used to define a baseline or quantify change and where detailed contextual information such as soil type can be used to help scale results. This includes data such as the NSIS, LUCAS and BioSOIL.
- Data that are collected as part of the national frameworks such as data from the Scottish Government's Whole Farm Plan, legacy soil sealing data from within local authorities, data on soil contamination, LCA and EIA data and peatland condition data sets.
- Soil data which is supplemented by detailed information on changes in management practices such as that from living labs.
- Datasets that are collected as part of Nature-Related Financial Disclosures and Carbon and GHG reporting and data collected within platforms for agricultural monitoring and decision making.

Combining data from local authorities, agricultural reform and other commercial sources with statistically robust monitoring data could help refine baselines of soil properties and provide a bigger matrix of land management change combined with climate and soil types to help understand the drivers of change. To ensure this kind of data can be used to its maximum potential requires:

- The definition of standard protocols for data collection and laboratory analysis including procedures for recording standard meta data
- The ability to store and manage the data together whilst ensuring data protection including where regulatory thresholds of indicators exist.
- The build-up of trust where the value of combining the data is seen for creating informed policies and recommendations and robust model predictions.

There are also data sets and methods that can provide data to support soil monitoring. This includes the Scottish Government's LiDAR (Light Detection And Ranging) data. This is data from aerial scanning that provides high resolution model of the earth's surface. The raw data includes details of the vegetation surface and can be used to calculate parameters such as the amount of carbon in forestry. The data can also be processed obtain a microtopographic surface that can be used to identify things like flow pathways. LiDAR itself does not measure soil health but can provide a proxy of vegetation response to soil degradation and could provide the identification of areas where further soil data maybe required.

There are a range of pathways in which data is collected in agriculture that could be better harnessed to support a national soil monitoring programme. Farm data sets being reviewed as part of RESAS Underpinning National Capacity by SRUC include historical and more recent SAC on-farm data collected as part of the farm advisory service. Another opportunity is through Scottish Government's Whole Farm Plan[141] (WFP) rolled out as part of the

Agricultural Reform Programme[157]. As part of the WFP, Scottish farmers and crofters will have to demonstrate that they have started to review and baseline their current land (and livestock) management practices and are considering appropriate actions towards more sustainable, efficient and resilient agricultural activities to receive Basic Payment Scheme (BPS) payment and deliver Scotland's Vision for Agriculture. The Whole Farm Plan includes soil analysis is required for all region 1[158] land that a farmer or crofter manages on a permanent basis (with the exception of seasonal land and common grazing shares) that they apply artificial fertilisers and/or organic manures. The soil data collected through this process is to enable farmers and crofters in their decision-making and currently not collated or stored by Scottish Government. There are challenges to collating national-scale soil data (see Appendix I of the Soil Route Map for Scotland Report 2025[1]) but also opportunities that could be explored further, for example the WFP data could provide a mechanism for assessing the effectiveness of Agri-Environmental Schemes. Data could provide insight to soil condition with respect to different land management practices, land use change and climate variation and therefore support a national soil monitoring framework.

The potential 'Big Data' generated from farm-scale monitoring may help give an overall picture of national soil condition within agricultural sector but there are potential biases due to differences in methods used to collect the data and the fact that the locations sampled may not be representative. Integrating data from farm-scale monitoring with data from a statistically robust monitoring scheme it would increase the value of the 'Big Data' and allow an assessment of any biases which may be in it.

The use of this data would require:

- Spatial locations of the fields (if an aggregated sample is collected from a field) or sampling points (if a set of individual points) so the data can be linked to farm management and mapped soils, landscape and climate data.
- The recording of consistent metadata is essential to account for possible differences in:
    - How samples were taken in a field or over an area in non-cultivated sites. For example: whether one point it sampled to represent an area or whether samples from a series of points across an area are taken and aggregated.
    - The analytical methods for example the temperature at which loss on ignition (a measure of carbon in the soil) is analysed, where higher temperatures will lead to greater values that would need to be taken into account if they were to be used with data from analysis at lower temperatures.

There are data management considerations that would need to be reviewed such as accounting for differences in sampling and analytical methods and potential issues of data ownership.

[157] https://www.ruralpayments.org/topics/agricultural-reform-programme/arp-route-map/ (Accessed May 2026)

[158] https://www.ruralpayments.org/topics/your-business/regionalisation-of-payments/ (Accessed May 2026)

E2: Datasets reviewed within Scotland's national soil monitoring framework

Types of data	Data value and questions	Challenges and considerations
Data from national Monitoring (NSIS)	Baselines with soil profile descriptions on a 5km grid (See NCEA and EU soil monitoring law for the need for these)	Need for consideration of number of points on different land covers particularly when looking at questions on exploring the impacts of land management practices
	Statistically robust so can be used to assess Bias in other data sets	
	Covers main soils and land covers and rare soils	
	Provides a basis for things like spectral libraries for developing models for the prediction of properties like IR that can be used to develop rapid methods	
Forestry data	Profile descriptions and data from BioSOIL[159] forest survey.	Soils data collected to comply with the UK Forestry Standard (UKFS). Including collected for Felling permission, Environmental Impact Assessment (EIA) or the Forestry Grant Scheme. Information on Scotland's Soils Website
	The National Forest Estate soil maps[160] provide detailed soil type information for parts of the Public Forest Estate	
	Soils data collected to comply with the UK Forestry Standard (UKFS)[50]. Including collected for Felling permission[161], Environmental Impact Assessment [162](EIA) or the Forestry Grant Scheme[163]. Information on Scotland's Soils Website	
Peatland data from Peatland Action	Management and mapping	Potential for missing other organic soils if peat is just defined by depth of organic layer and the value of the profile information e.g. poorly or more freely drained
	Characterises degradation and full peat depths	

[159] https://www.ukso.org/static-maps/forest-research-biosoil-data.html (Accessed May 2026)

[160] https://www.ukso.org/static-maps/national-forest-estate-soil.html (Accessed May 2026)

[161] https://www.ukso.org/static-maps/national-forest-estate-soil.html (Accessed May 2026)

[162] https://www.forestry.gov.scot/forestry-environmental-impact-assessment (Accessed May 2026)

[163] https://www.forestry.gov.scot/available-funding-and-support (Accessed May 2026)

Types of data	Data value and questions	Challenges and considerations
Third Party soils data	Wide range of data that includes commercial data and data from reporting for financial disclosures.	Challenge of consistency of across data collection approaches Significant challenges with data confidentiality, governance and accessibility that restricts the potential to consolidate. Also potential challenges with Bias in the data sets.
Catchment data	Data on the impacts of soil degradation including water quality and quantity or wildfire occurrence that can be linked to soil monitoring data. For example: SEPA water quality data and water level data and NatureScot Wildfire and MuirBurn Extent	Understanding representativeness of catchments in order to scale the results and draw national conclusions.
Data on soil sealing	Part of EU planning laws to report on sealing - "No net land take" and 3 yearly reporting	Understanding of unsealed areas using a resolution of satellite data in Urban areas
	Impacts of soil sealing on water quality and flooding	Split of data in councils
	Use of historical planning data	
	Analysis from remote sensing	
Data from Environmental Impact Assessments	Soil information from Scottish EIAs data is divided by sector (planning, agriculture, forestry)	Split of data in councils
Data from Specific farms Living Labs and Lighthouses	Combining detailed farm data with management data to explore interactions and the ability to test new methods against established ones.	Representatives of living labs for use in wider scaling and monitoring
	Use for communication of results on impacts and methods for the application of nature-based solutions and measures	
Data from agricultural reform	Big data for statistical methods	Need for consistent methods and measures in laboratory and field
		Laboratory capacity

E3: Description of the National Soil Inventory for Scotland (NSIS)

Scotland (NSIS1) where they described a soil profile every 5km (3126 locations) across Scotland and described and sampled the soil profile every 10km (721 locations). Soil profiles were described and characterised in a way that defines their soil function (e.g. how they respond to rainfall) and soil horizons were sampled. In 2007-2009 a representative sub-set of original 10km samples (~ 190 c. 25% on a 20km grid) were resampled (NSIS2) with the addition of samples from rare habitats and soils that would otherwise be missed or under-represented. The aim was to sample the top 20-30 most common soil type/land uses across Scotland. This data set provides a baseline for a wide range of novel indicators, including biological properties (e.g., phospholipid fatty acid profiles and eDNA), emerging contaminants and information from new techniques such as Infra-Red spectroscopy and X-ray diffraction that could provide baseline data for indicators of soil health across a wide range of land covers including agricultural land.

Sampling by horizon means that the subsoils are sampled as well as the topsoils and the depth of each horizon is recorded. This allows total carbon stocks to be calculated, whereas most other data sets only include data on topsoils. It also provides baseline data to assess change in subsoils that aligns with the EU soil monitoring and resilience directive where subsoil bulk density is an indicator in addition to being linked to the calculation of soil profile carbon stocks. Measuring indicators in subsoils can also be used to better characterise potential changes in runoff that are not only associated with changes in topsoil properties (Baggaley et al., 2024). Knowing the soil type (characterised by the sequence of horizons and their properties) at each point also provides important contextual information for using measured indicators in modelling approaches. A systematic sampling scheme, with time series of data, with known soil types and information on land cover and management can also be used to increase the value of other sampling campaigns, aimed at answering specific scientific or policy questions.

Appendix F Options for action for soil protection, restoration and enhancement

F1: Initial actions with some indication of readiness for implementation

Actions are already in progress or could be readily initiated with some investment of resources

These options would need more research and/or resources to initiate

Option		Readiness to implement in the short-term	How the option could evolve in the longer-term
T1-O1	Develop Scotland-specific guidance to support soil protection, restoration and enhancement in Local Development Plans (LDPs)	Soil management guidance relevant to Scottish soils can be provided and updated and/or supplemented as new research becomes available	Research into best practice relating across different soil types and a range of development types. Monitoring soil health characteristics during and post construction would provide valuable insight to inform best practice
T1-O2	Expand guidance for identifying and protecting carbon-rich soils	This can be implemented in the near-term and updated and/or supplemented as new research becomes available	Developments to Scotland's soil carbon maps would need significant investment and coordinated alongside national surveying and/or soil monitoring
T1-O3	Develop targeted guidance for conducting Land Capability for Agriculture (LCA) assessments	This can be implemented in the near-term and updated and/or supplemented as new research becomes available	Research is ongoing within Scottish Government's SRP which may provide updated tools for LCA assessment
T1-O4	Review and develop guidance of soils within EIAs	The use of IEMA (2022) guidance can be implemented as a condition of proposals relating to Scottish soils in the near-term and developed further as new research becomes available and EIA guidance progresses	Developing the IEMA (2022) guidance further would be beneficial. E.g. more detail relating to the sensitivity and potential impacts of different activities (see T1-R1)
T1-O5	Review opportunities to better link the sustainable management of soils during development projects to support wider environmental net gains	Qualitative connections between soil management and wider net gains can be provided, however further research would be needed to provide more quantitative estimates	This aligns to T4-R3 and T5 to investigate more quantitatively the role of soils in ecosystem service provisioning. However, research that aligns to this is already ongoing within Scotland's SRP

Option		Readiness to implement in the short-term	How the option could evolve in the longer-term
T1-O6	Develop procedures which promote the sustainable use and reuse of Scottish soils	Some initial recommendations could be provided to support more soil reuse in Scotland; however, some research would be needed to develop this further into a more bespoke framework across Scottish soils and development contexts	Invest in research into best practice and scoping mechanisms to improve logistical and regulatory considerations
T2-O1	Develop cross-sector guidance on soil compaction and soil physical degradation	There are evidence and guidance available to provide recommendations to identify and alleviate soil compaction across Scottish soils	As research develops there are opportunities for guidance to become more detailed and bespoke across different soil and land use types
T2-O2	Explore opportunities for soil compaction to be identified and alleviated through existing programmes	For certain sectors like agriculture, there are already frameworks (e.g. WFP) where soil compaction tests could be implemented. For other land uses this may require additional resource or guidance or initiatives to promote uptake	There is scope to review pathways to implement soil decompaction (where needed) across different sectors and soil types
T2-RO3	Update guidance and tools informing the risk of Scottish soils to physical degradation and compaction	Estimating soil vulnerability can be complex and so will require investment into data collection and analysis (as well as mapping) to develop these further	Future opportunities to expand the application of the soil vulnerability maps to further link soil vulnerability to land capability, land use, ecosystem services and climate risks
T3-O1	Support the identification and remediation of contaminated soils	Evidence shows the range of soil remediation techniques available, however LAs need resource support to promote further implementation	Support LAs to identify and remediate
T3-O2	Review and further develop guidance to support nutrient management planning in agriculture	This is planned with the introduction of the Nutrient Management Planning within the WFP	Possibility to evolve nutrient planning support to develop upon WFP
T3-O3	Develop research and guidance on the application or soil amendments for nutrient management	There is currently limited evidence that fully captures the net effects of novel amendments from which informed guidance for the application to soils can be provided	Scope the range of products being used and applied to soils. Investigate evidence to provide guidance and to assess whether the use of certain products should be regulated

Option		Readiness to implement in the short-term	How the option could evolve in the longer-term
T3-O4	Monitor progress of the Whole Farm Plan	Straightforward in principle, however there are data management issues that need consideration	Work needed to consider GDPR, financial resourcing of a centralised database, governance and data accessibility
T3-O5	Advance research on forever chemicals and emerging contaminants in Scottish soils	This is already occurring to an extent However more insight would support the progression to identify key sources, pathways and receptors of new contaminants	Scope how emerging contaminants may need to be regulated and effective soil remediation options for new contaminants
T4-O1	Continued support for peatland restoration and woodland creation	This is included within Scottish Governments policy objectives	Future work could involve incentivising private investment to support further peat restoration dn woodland creation
T4-O2	Review policies for aligning a soil monitoring framework with environmental sustainability reporting standards	With some consideration, there is scope to better align soil indices monitored across different frameworks and/or provide guidance on the appropriate use and interpretation of Scottish soil data in environmental reporting	As Scottish soil monitoring programme develops (Theme 5), further knowledge can be fed into wider frameworks
T4-O3	Review policies for aligning a soil monitoring framework with nature-based frameworks		
T4-O4	Develop guidance on appropriate use and limitations of soil metrics in corporate reporting and verification	Guidance on the limitations of different soil metrics can be provided and updated or supplemented as new research becomes available	As Scottish soil research develops, further knowledge and guidance can be provided
T4-O5	Incentivise further mobilisation of soil protection, restoration and enhancement through the adoption of financial frameworks	This is included within Scottish Governments policy objectives for broader nature incentives. For more soil-specific incentives, further work would be required to develop operational frameworks	As Scottish soil policy and research develop, further knowledge and guidance can be fed into the development of new incentives to mobilise activities for soil protection, restoration and enhancement
T5-O1	Review strategic objectives in the soil framework	This is in progress within Scottish Government's strategic research programme and wider research	As Scottish soil research develops, further knowledge and guidance can be fed into the development of a soil monitoring framework
T5-O2	Support the design of a monitoring framework based on the integration of data sets from different sources	This is in progress within Scottish Government's strategic research programme and wider research	As Scottish soil research develops, further knowledge and guidance can be fed into the development of a soil monitoring framework

Option		Readiness to implement in the short-term	How the option could evolve in the longer-term
T5-O3	Develop research to provide robust scientific data to support the use of novel indicators in soil monitoring	With some consideration and investment, scoping the robustness of different applications to inform changes in soils can be assessed	As Scottish soil research develops, further knowledge and guidance can be fed into the development of a soil monitoring framework
T5-O4	Review the potential for collation and use of supplementary data	With some consideration and investment, the potential to align and/or amalgamate different sources of oil data can be made.	As Scottish soil research develops, further knowledge and guidance can be fed into the development of a soil monitoring framework
T5-O5	Support Scotland's Soil Website to host soil data, guidance and tools	This is included within Scottish strategic research programme	As Scottish soil knowledge develops, the Scottish Soil Website can provide a centralised resource to provide core knowledge and guidance

F2: Co-delivery of multiple policy objectives

Protecting soils for co-delivery of multiple policy objectives

Policy	Context in which soils are mentioned	Physical loss (erosion)	Physical degraded. (compaction)	Conservation of OM and C	Soil biology & biodiversity	Soil chemical health	General soil health/ protection
Scottish Soil Framework (2009)[5]	A detailed document outlining risks to Scottish soils and suggested actions for soil security	Y	Y	Y	Y	Y	Y
Scottish Biodiversity Strategy and Delivery Plan, 2024[94]	The Scottish Biodiversity Strategy 2024 offers "key actions include: protecting soils and enhancing soil health; reducing and targeting the use of inputs; and protecting water courses from run off. Building soil organic carbon helps retain moisture in the soils, maintaining a good diversity of living roots in the soil improves soil structure and water infiltration. Peatland restoration also makes a significant contribution."	Y	Y	Y	Y	Y	Y
Scotland's National Peatland Plan and Peatland Action[164];	"Scotland's National Peatland Plan provides a framework for recognising, communicating and, where appropriate, quantifying the benefits of healthy peatlands and marshalling the knowledge, skills, incentives and funding to improve the condition of those which are damaged or degraded. It will bring together representatives from a wide range of interests to form the National Peatland Group, chaired by Scottish Natural Heritage to drive forward this important agenda."	Y	Y	Y	Y	Y	Y

[164] https://www.nature.scot/doc/scotlands-national-peatland-plan-working-our-future (accessed May 2026)

Policy	Context in which soils are mentioned	Physical loss (erosion)	Physical degraded. (compaction)	Conservation of OM and C	Soil biology & biodiversity	Soil chemical health	General soil health/ protection
Agricultural Reform Programme (List of Measures)[104]	Provides the 'Agricultural Reform List of Measures', many of which relate to soils. For example - Continuous Soil Cover; Efficient/reduced use of synthetic inputs; Crop diversity (grassland); Retain and enhance field margins and permanent habitat margins; Restore and manage existing nature rich habitats; Nutrient management. These measures contribute to reducing soil greenhouse gas (GHG) emissions; Increasing soil carbon/organic matter content; Increasing resilience to weather events; Improving soil nutrient content; Reducing diffuse pollution; Improving water and air quality; Improving soil water retention and flow; Improving soil biodiversity; Removing drivers for biodiversity loss).	Y	Y	Y	Y	Y	Y
Agricultural Reform Programme (Cross Compliance)[165]	Good Agricultural and Environmental Conditions (GAECS): maintaining a minimum soil cover (GAEC 4), protect soil against erosion after harvest, to protect soil against erosion in certain situations (GAEC 5) and maintaining soil organic matter levels (GAEC 6).	Y	Y	Y	x	x	Y
(5th) edition of the UK Forestry	Soils are discussed throughout with particular reference in section 8 - UKFS Requirements for Forests and Soil, where there is specific guidance on minimise disturbance and risks associated with waste management and waste application, acidification, contamination, compaction, erosion, decline in fertility and function and protecting soil organic matter and carbon contents	Y	Y	Y	Y	Y	Y

[165] https://www.ruralpayments.org/topics/agricultural-reform-programme/cross-compliance-quick-guide/ (Accessed May 2026)

Policy	Context in which soils are mentioned	Physical loss (erosion)	Physical degraded. (compaction)	Conservation of OM and C	Soil biology & biodiversity	Soil chemical health	General soil health/ protection
Standard (UKFS) (2023)[166]							
Scotland's National Planning Framework 4[5]	Part 2 - Sustainable places (policies 1-13) in particular, Policy 5 - To protect carbon-rich soils, restore peatlands and minimise disturbance to soils from development by protecting and restoring valued soils; that soils, including carbon-rich soils, are sequestering and storing carbon and that soils are healthy and provide essential ecosystem services for nature, people and our economy	Y	Y	Y	Y	Y	Y
Building standards technical handbook 2020: domestic, 2020 [50]	Soils are mentioned throughout in terms of site preparation, drainage, flood risk, contamination and developments. It is acknowledged that water, air and soil are intricately linked and all can be affected by various forms of pollution that affect our environment. Therefore, assessment of risks are advised	x	Y	x	x	Y	Y

[166] The UK Forestry Standard - GOV.UK

Policy	Context in which soils are mentioned	Physical loss (erosion)	Physical degraded. (compaction)	Conservation of OM and C	Soil biology & biodiversity	Soil chemical health	General soil health/ protection
The 3rd Scottish National Adaptation Plan (2024)[2]	Soils widely discussed, in particular NC2 Objective - Landscape scale approaches - Landscape scale solutions are implemented for sustainable and collaborative land use, including protecting and enhancing Scotland's soils. Scotland's soils are at increasing risk from the impacts of climate change, including flooding and drought. As soils are found across different landscapes performing multiple ecosystem functions, a landscape scale approach to improving soil condition and quality is needed. Also NC6 Natural Carbon Stores and Sinks (such as peatland, forests and blue carbon) which are supporting Scotland's net zero pathway, alongside timber production, biodiversity gains, flood resilience and the priorities of local communities.	x	x	Y	x	x	Y

F3: How PREn1 objectives can support the Scottish Biodiversity Delivery Plan 2024–2030

Actions needed to achieve Objective 2: protect nature on land and at sea, across and beyond Protected Areas		**PREn1 recommendations to support delivery**
12. Champion new planning and development measures for protecting and enhancing biodiversity	12.4 Provide guidance on sustainable use and management of soil in planning processes.	T1-O1, T1-O2, T1-O3, T1-O4, T1-O5, T1-O6
Actions needed to achieve Objective 3: Embed nature positive Farming, Fishing and Forestry		
14. Ensure increased uptake of high diversity, nature-rich, high-soil carbon, low-intensity farming methods while sustaining high-quality food production.	14.2. Develop a route map (end of 2025) for soil security in Scotland including a review and update of Scotland's Soil Framework and action/implementation plan (2030).	Soil Route Map 2025 and this addendum
	14.3. Develop evidence-based Soil Health Indicators that can be considered for inclusion in Whole Farm Plans and Forest Management Plans	T5-O1, T5-O2, T5-O3, T5-O4
	14.5. Improve information for land managers on how to assess and interpret soil erosion risks and implement measures to avoid erosion (and other impacts on soil health related to climate change), including: i) the impacts of extreme rainfall drought events on soils; and ii) maps of soils that have been subject to anthropogenic degradation and are candidates for soil improvement programmes.	T2-O1, T2-O3, T4-O1, T4-O5, T5-O2
	14.6. Develop and promote clear guidance for practitioners on soil compaction and farm and forestry machinery contractors are engaged in ensuring appropriate use of equipment, uptake of decision-making tools and training, to minimise and ultimately avoid compaction damage to soils.	T2-O1

	14.7. Set up monitoring frameworks to assess change in soil health, based on evidence from the Natural Resources theme of the Strategic Research Programme (2022-2027).	T5-O1, T5-O2, T5-O3, T5-R4
	14.8. Reduce inputs of nutrients to freshwaters that cause enrichment impacts on biodiversity, by controlling both diffuse and point source pollution through effective nutrient management through agricultural reform and SEPA's Priority Catchment programme, ensuring compliance with the Environmental Authorisations (Scotland) Regulations 2018 (EASR) under River Basin Management Planning.	T2-O3, T3-O2, T3-O3, T3-O4
15. Introduce an agricultural support framework which delivers for nature restoration and biodiversity alongside climate and food production outcomes.	15.1. In 2025, as part of eligibility requirement for Basic Payment Scheme, businesses must undertake two from the following five baselines: biodiversity audit, carbon audit, soil analysis, animal health and welfare plan and integrated pest management plan as part of a revised rural payments process that encourages Nature Positive activities	T3-O2, T3-O3
	15.3. In 2025 there will be new peatland and wetland standards under Cross Compliance which will prohibit a range of activities from being carried out on peatland and wetland areas. We will continue to develop rural support mechanisms to incorporate further requirements to protect and enhance soil health, promote control of soil erosion/compaction and maintain/enhance soil organic matter through appropriate balance of input/outputs and nutrient levels.	T4-O1, T2-O3, T4-O5

Appendix G Next Steps for Developing Soil Knowledge in Scotland

G1: Areas of research interest, ENRA Strategy 2027 to 2032

Areas of research interest outlined in Scottish Government's Environment, Natural Resources and Agriculture Research: Strategy 2027 to 2032 that directly and indirectly support future progression of soil knowledge in Scotland.

Mission	Challenge	Areas of Research Interest
Delivering sustainable and regenerative agriculture and food systems	Maintaining a high plant health status	What impacts will other policies have on plant health and how can plant health be embedded across multiple policy areas?
	Reforming Scotland's agricultural system	How can research embed and support Regenerative Farming in Practice in Scotland?
		How can we understand the interactions in the land system and agriculture in Scotland?
	Promoting crop & livestock improvement	How can we develop novel crops which are suitable for a changing environment?
		How can we develop crops and food systems which reduce fertiliser and chemical usage?
	Ensuring Scotland's food is safe	What is the impact of climate change on food safety in Scotland, and how do we mitigate such risks?
	Building resilient food systems for food security	How should we understand the economic opportunities and risks to the Scottish Food and Drink sector from new developments and innovations in agri-food?
Restoring nature and protecting our environment	Protecting and restoring Scotland's soils	What soils data, metrics, and other information do we need, across the full continuum of Scotland's soils from mineral to deep peats, to understand the current land status and to develop policy-relevant insights?
		What is the impact of climate change, extreme weather and variability on soil function, across the full continuum of Scotland's soils from mineral to deep peats, and its relation to water and biodiversity?
		What does healthy soil biodiversity and biological activity look like for different ecosystems and land management systems (for example, including agricultural, urban, semi-natural and peatland)?
	Protecting and restoring Scotland's peatlands	What does successful peatland restoration look like, now and in the medium and long-term?
		Which peatland data gaps should be addressed as a priority?
		How does renewable and other energy infrastructure impact carbon rich soils in Scotland?
		What do we need to know to improve the management of Scotland's biodiversity and landscapes?

Mission	Challenge	Areas of Research Interest
	Restoring and regenerating biodiversity	What data do we need to collect to allow for practical measurement, evaluation and assessment of biodiversity to understand species status, habitat condition and ecosystem health to underpin improvements?
	Enhancing Scotland's environmental quality and resilience	How can Scotland build resilience to climate change from both a water quality and quantity (scarcity and flooding) perspective?
		How can we better understand the risks of coastal erosion?
		What do we need to know about pollutants and their impact on Scotland's environment (water, land and air)?
		How can we better prioritise which chemicals to focus on in Scottish chemical policy?
	Investing in Scotland's natural capital	What regulation and frameworks (including voluntary codes and approaches) are needed to promote high-integrity, sustainable private nature finance and investment in Scotland?
		What evidence is needed to appraise and evaluate interventions related to Natural Capital, Nature-Based Solutions and private nature finance?
		What supports effective landscape-scale nature restoration and nature-based solutions?
		What evidence do we need to support a Natural Capital approach in Scotland?
Delivering climate-positive and resilient landscapes	Adapting to climate change	What data do we need to have to build Scotland's resilience and adaptation to Climate Change?
		How can we maximise the potential of behavioural research to support our rural communities and the wider environment?
	Optimising Scotland's land use	How should we understand the interactions in the Land use and Finance systems?
		Which new data, modelling, and systems-thinking is needed for land use in Scotland?
Building the circular economy	Maximising the circular economy and reducing waste	How can technology and modelling approaches be further developed to improve our understanding of changing system and infrastructure needs in the transition to a circular economy?
		How can we further develop our understanding of key waste materials?
Delivering climate-positive and resilient landscapes	Adapting to climate change	How can we take a systems-based approach to adapt to climate change in the ENRA policy areas?

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