Written Evidence submitted by The Greenhouse Gas Removal Hub (CO_2RE) and the GGR-D Programme(SH0048)

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

Healthy soils are a vital component of healthy ecosystems, and are critical in supporting essential ecosystem services, including food security and climate change mitigation and adaptation.

Progress towards all soils being sustainably managed needs to be measured in two ways: 1) monitoring the uptake of sustainable soil management actions, and 2) direct sampling of soils to understand trends in soil health and the effectiveness of the actions targeting improvements.

Relevant management actions to improve soil health include use of cover crops, reduced tillage, incorporation of organic matter [1], reduced use of agro-chemicals [2], agroforestry, and (in areas vulnerable to soil degradation) arable reversion to grassland or other habitats, or reduction of continuous grazing pressure. These can largely be captured as the uptake of agri-environment options including existing Countryside Stewardship and organic agreements, and new Environmental Land Management (ELM) scheme options. However, some options such as agroforestry are not yet fully covered under these schemes and should be monitored separately (see answer to q. 3 on ELMs below). Also, not all land managers implementing these practices are signed up to an agri-environment scheme, so efforts should be made to contact and monitor people implementing these actions without claiming payments.

Direct sampling of soils is more challenging but is essential to confirm and reward improvements in soil health and refine management methods to be more effective.

Monitoring is needed because soil is a complex ecosystem that may show different responses to interventions depending on local biophysical conditions and management history. A UK-wide MRV framework should be established as soon as possible, with the breadth of coverage to ensure progress towards national goals, informed by detailed, local-level monitoring. This should include a large-scale surveying scheme to establish a baseline from which to confirm increases in soil carbon and improvements in soil health.

For maximum cost-effectiveness, surveys should use the same samples and field/lab testing time to capture multiple components of soil health and function, including soil carbon for emissions accounting, chemical properties for environmental and agricultural monitoring, and soil biodiversity to monitor nature recovery. This is important because there is a major evidence gap on soil biodiversity [3] and it may not be possible to infer soil biodiversity from aboveground biodiversity assessments [4].

Repeated national and sub-national soil surveys should be an important component of a soil MRV programme, and should cover different land-uses, management practices, and climatic conditions [5]. There is long-running soil survey through the National Soil Inventory [6] (with separate inventories for England + Wales and Scotland), but this has been quite infrequent, and does not track land use and management between surveys. Farmers may also be conducting their own soil surveys, especially where they practice precision agriculture, and there is funding available under the Sustainable Farming Incentive for completing soil assessments and producing soil management plans, and testing soil organic matter (under 'grassland' and 'arable and horticultural' soils standards). There may be opportunities to include farmer or agronomist sample data in a national survey if confidentiality and reliability concerns can be overcome.

Soil survey data should be linked with other environmental monitoring programmes, particularly the UK greenhouse gases flux network to confirm carbon removal and explore impacts on other land and agriculture related emissions fluxes [7]: expanding this network could also prove valuable, given the significant role of the land sector in achieving net-zero. A UK monitoring effort should be harmonised with other international standards for measuring soil health, such as those in the EU [8] and US [9]. The UK should also align research efforts into the processes underpinning soil health and soil quality MRV with the international research community.

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

Current options for agricultural land under ELMs

There are a number of actions in the Sustainable Farming Incentive (SFI) Environmental Land Management (ELM) scheme targeting soil health improvements for specific agricultural land-uses. For this submission, we highlight some areas where there may be significant potential to improve agricultural soils (and provide additional benefits), but it remains unclear how and to what extent they are supported through current payment options.

Trees in agricultural systems ('agroforestry') can contribute to soil health, increase soil carbon [10] and support regulating ecosystem services (e.g. erosion control, flood mitigation, nutrient cycling), in addition to the benefits to biodiversity and above-ground carbon storage provided by the trees themselves – although there is a relative lack of experimental evidence or exploration of different types of agroforestry in higher-income countries, such as the UK [11]. Agroforestry may also be increasingly beneficial as global warming continues, providing adaptation through greater agroecological resilience [12].

A recent ELM update [13] states "*[i]n addition to what we are already paying for, we plan to pay for the establishment and maintenance of silvoarable and silvopastoral agroforestry systems. This means integrating trees into arable fields or grazed grassland. Managing the land under the trees would be paid for through the actions covered in the sections on grassland and arable land*." There remains relatively little detail on what this will look like. For grazing, this may be encompassed by the 'creating wood pasture' Countryside Stewardship options (actions WD6 and WD12, for lowlands and uplands respectively), but is not clear if there will be alternative routes. Both wood pasture creation options suggest recipients will likely not be allowed to "apply fertilisers or manures" (among other restrictions), and while this may ensure some soil health and wider benefits, it could also be an unnecessary deterrent for some land managers to establish silvopastoral systems that could prove environmentally superior to conventional grassland management, even if limited amounts of fertiliser are applied. Similarly, under the Countryside Stewardship actions for protection of in-field trees in arable (BE1) and intensive grassland (BE2), trees must be surrounded by a grass buffer sward up to 30m surrounding the tree (for the largest trees) with restricted management options: while these will likely support a number of environmental benefits, some flexibility may be useful in the future if a case can be made for beneficial agroforestry systems with agricultural interventions being undertaken closer to trees.

Including a grass ley period in arable rotations can increase soil carbon and improve soil health. Some recent research suggests that sufficiently long leys (3-4 years within a 10 year overall rotation) can help increase soil carbon below the topsoil [14]. Longer-term, mixed arable and grassland rotations are arguably under-researched and under-utilised (especially outside of organic management), but may confer agronomic and environmental benefits. Within the ELMs (following definitions in previous rural payment schemes), once an area has been grass for more than 5 years, it is classified as 'permanent grassland', and cannot go back to arable management. Some flexibility could be useful here in future if clear evidence emerges that grass leys of 5+ years can provide significant benefits within an arable rotation. However, there should still need to be exclusion and monitoring to avoid truly 'permanent' grassland being converted to arable land, which would negative consequences for soil carbon and health.

Soil amendments for carbon sequestration

The Royal Academy of Engineering and the Royal Society Greenhouse gas removal report [15] also includes biochar and enhanced rock weathering as potential CO_2 removal methods. Although these are not included in current Committee on Climate Change net-zero pathways (as not currently possible at scale in the UK), they may contribute significant carbon sinks in the future, and may have significant soil health impacts.

Biochar is pyrolysed biomass, making it slower to decompose, and biochar addition could provide a significant, but finite, carbon sink [16]. There is also some evidence that biochar addition can improve soil health, changing soil properties and increasing plant growth, but the dynamics are specific to location, management, and biochar properties [17].

Enhanced rock weathering (or 'ERW') is the addition of crushed basalt or silicate-rich waste to soils, which can react with CO_2 to form bicarbonate and carbonate anions that can eventually run-off to the ocean where they may be deposited, resulting in a long-term carbon sequestration. It has been suggested that ERW can also improve soil productivity [18] and even support coral reef biodiversity by reducing ocean acidification downstream [19]. However, there are also risks in toxic metal contamination of soils (depending on rock source), alongside other environmental impacts upstream in the supply chain (mining, if not using waste materials, energy use in rock crushing and transport), and potential downstream water quality impacts (increased turbidity and sedimentation) from the crushed rock [20].

Further research will be required to ascertain the sustainability of biochar and ERW, and their potential role as a CO_2 removal technologies and soil health improving measures in the UK, before policy-makers consider whether or how best to support them as potential options. Long-term monitoring (of soils and wider environment) should also be prioritised where these practices are deployed, as long term effects are largely unknown.

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

In the wider food and agriculture sector, pressures on land-use could be reduced through efforts across the food system, including demand-side nudges, reducing post-harvest food losses, and sustainably improving productivity (through, for example, improved animal health and ensuring uptake of best agronomic practice). These measures could also provide significant reductions in food and agriculture related greenhouse gas emissions [21]. Shifting average diets to be more in line with existing government advice ('The Eatwell Guide') to consume fewer total calories and a lower share of animal-sourced foods [22] would provide a significant demand-side intervention. Government could support this through implementing recommendations in the National Food Strategy [23], for example, basing public food procurement practices on these guidelines [24]. This could provide food for a similar proportion of the UK as currently supported through domestic production, but permitting less intensive cultivation practices (as outlined above), while also increasing the share of land available to prioritise nature recover.

Achieving these targets requires looking beyond the food and agriculture sector. Pressures on land use from urban development must also be reduced, which could be tackled by promoting more compact developments in the planning system (e.g. 'gentle densification' though use of mid-rise buildings) [25]. It is also important to integrate soil health into policies on ecosystem restoration, forestry and bioenergy as described below, and to tie these policies together in the forthcoming land-use strategy.

Ecosystem restoration

Soil health and the beneficial services provided by soils extend beyond agriculture, and in particular, soil health should be highlighted as one of many reasons to provide policy support for ecosystem restoration. Furthermore, the UK's net-zero strategy includes biosphere carbon storage through ecological recovery, primarily through peatland restoration and reforestation.

Peatland restoration is fundamentally a soil health measure, reversing anthropogenic damage to re-raise the water table, preventing carbon dioxide emissions (peatlands are currently a significant source) and eventually sequestering carbon [26], and potentially providing additional benefits, such as natural flood management [27].

Reforestation (tree planting on sites where the native vegetation cover in the absence of anthropogenic management would be forest) is highlighted for its potential to store carbon in tree biomass and soils [28], help restore biodiversity, and provide additional (partly soil-mediated) benefits such as flood management [29]. Tree-planting on previously agricultural lands results in initial soil carbon losses [30]. On mineral soils it is expected that this will eventually contribute net carbon gains. However, planting on more organic soils (even on shallow peat, which is currently allowed under the UK Forestry Standard) can lead to an overall loss in carbon, and should therefore be avoided [31].

As woodland and forest restoration ramps up as anticipated under the net-zero land use pathways, research should explore different planting methods to minimise soil disturbance, and best practice guidance updated to reflect findings. This should include more support for natural regeneration and rewilding, which we anticipate would result in resilient, biodiverse and carbon-rich landscapes [32].

Forestry and bioenergy

Net-zero land-use scenarios suggest increases in plantation forestry alongside native woodland creation, contributing carbon sequestration through standing biomass and increased soil carbon, and supplying harvested wood for bioenergy with carbon capture and long-lived wood products. It should be noted, however, that this would represent a major change from the current situation, where around 84% of harvested wood in the UK goes to short-lived products (panels, fencing, pallets and packaging) or wood fuel [33]. There is also a drive to 'bring all woodlands into active management', but over over-extraction of biomass to meet a significant increase in the demand for harvested wood to achieve net-zero could have adverse impacts on soil health, soil carbon and biodiversity. Guidance should ensure that harvesting from semi-natural woodlands is strictly in-line with nature recovery objectives, and in particular that there is minimal extraction from shrub understory, deadwood, or large fully mature trees [34]. Similarly, the use of salvage logging following disturbance (predicted to increase with climate change), should be kept to conservative levels, as keeping surviving trees and deadwood in situ can maintain soil health and contribute to forest resilience and is essential for nature recovery [35].

These net-zero pathways also anticipate a significant increase in area of specific bioenergy crops: *Miscanthus*, short rotation coppice and short rotation forestry. While models suggest these can also result in increased soil carbon compared to previous agricultural land use [36], large-scale production of these crops for bioenergy is still a relatively novel strategy: details may be site-specific, and best management practice (for soil health and to minimise other environmental impacts) should be informed by ongoing research and monitoring [37].

Overarching land use framework

Large scale transformation in land-use and practices will be necessary to achieve significant government policy objectives (net-zero GHGs, nature recovery). Doubt has been expressed as to whether the present ELMs provide sufficient remuneration [38] or are broad enough to drive the extensive change suggested as being required (although the Landscape Recovery component may play a role in supporting this). It is thus unclear at present how overarching land-related ambitions will be fulfilled.

The Department for Environment Food & Rural Affairs has committed to publishing a land use framework in 2023 [39], and this could prove valuable in setting out a vision and clear priorities to drive land transformation at the necessary scale, and ensure that transitions are locally appropriate and implemented in such a way to maximise wider benefits and avoid or minimise any trade-offs, without becoming entirely prescriptive at the finest scales. It will be important to prioritise soil health in this framework.

Furthermore, an overarching framework can help to ensure integration where it is sensible to combine practices, and provide continued monitoring and evidence for how different managements interact with respect to soil health and other environmental outcomes; especially important given the interest in rapid scaling of relatively novel practices (biochar, ERW, bioenergy crops).

Authors

We are a group of academics (listed below) with interests and experience in agriculture, biodiversity, soil science, and land-based carbon sequestration. This submission also draws upon ongoing work being undertaken as part of a number of projects:

The Greenhouse Gas Removal Hub (CO$_2$RE) and the GGR-D Programme

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February 2023