



# An Overview of National Soil Monitoring Schemes Across the Four Nations of the UK

Developed by Prof. Bridget Emmett (UKCEH) and Ellen Fay (SSA) for the LUNZ Topic Advisory Group on Soil Health and Carbon Dynamics



**UK Research  
and Innovation**



Department  
for Environment  
Food & Rural Affairs



Department for  
Energy Security  
& Net Zero



Department for  
Science, Innovation,  
& Technology



Scottish Government  
Riaghaltas na h-Alba  
gov.scot

## SECTION 01

# Overview of schemes submitted

# Schemes submitted to the overview analysis

| Country          | Commissioning organisation   | Delivery organisation(s)            | Name of scheme   | Abbreviated name   |
|------------------|--|-------------------------------------|--|--------------------|
| Northern Ireland | Department Agriculture, Environment and Rural Affairs  | Agri-Food and Biosciences Institute | Soil Nutrient Health Scheme - Core Baseline Sampling and Analysis Programme                                      | <b>SNHS</b>        |
| Northern Ireland | Department Agriculture, Environment and Rural Affairs  | Agri-Food and Biosciences Institute | Soil Nutrient Health Scheme - Research Work Programme on Carbon  | <b>SNHS</b>        |
| Northern Ireland | Department Agriculture, Environment and Rural Affairs  |                                     | Countryside Survey NI  | <b>CSNI</b>        |
| GB               | Not directly commissioned but funded by UKRI/NERC under National Capability (1978 funded by ITE; 1998& 2007 CS consortium of governments and CEH)              | UKCEH                               | Countryside survey GB  | <b>CS</b>          |
| Wales            | Welsh Government   | UKCEH                               | Glastir Monitoring and Evaluation Programme and Environment and Rural Affairs Monitoring and Modelling Programme | <b>ERAMMP</b>      |
| England          | Defra  | Natural England..... Etc            | England Ecosystem Survey/ NCEA etc   | <b>EES</b>         |
| England          | Defra  | Royal Botanic Gardens Kew           | Fungal Health Survey - Natural Capital and Ecosystem Assessment Programme  | <b>Kew-NCEA</b>    |
| UK               | EU (70% funded), FC (30% funded) BioSoil 2006, BioSoil 2021-2026 -DEFRA NCEA (100% England BioSoil sites), Scottish Government and DEIZN (100% Scotland sites) | Forest Research                     | BioSoil -soil and biodiversity network   | <b>FR BioSoil</b>  |
| European Union   | European Commission  | EC JRC EU Soil Observatory          | Land Use Change Area-frame Survey Soil Module  | <b>LUCAS Soil</b>  |
| UK               | EU (70% funded until 2010), FC (30% funded until 2010) FC funded %100 since 2010 to now NCEA (funds 2 ICP Forest Level II sites)                               | Forest Research                     | ICP Forest Level II Intensive forest monitoring network  | <b>FR II</b>       |
| UK               | EU (70% funded until 2006), FC (30% funded until 2006)   | Forest Research                     | ICP Forest Level I forest monitoring network   | <b>FR I</b>        |
| England & Wales  |  | Cranfield University                | NSI E&W  | <b>NSI E&amp;W</b> |
| Scotland         | Not directly commissioned but funded under RESAS   | James Hutton Institute              | National Soil Inventory of Scotland  | <b>NSIS</b>        |
| Scotland         | Not directly commissioned but funded under RESAS   | James Hutton Institute              | Trends in pollution of Scottish Soils  | <b>TiPSS</b>       |
| Scotland         | Not directly commissioned but funded under RESAS   | James Hutton Institute              | Birse and Robertson Survey soils   | <b>R&amp;B</b>     |
| Scotland         | Forestry Commission Scotland   | James Hutton Institute              | Afforested soils   | <b>Afforested</b>  |
| Scotland         | Not directly commissioned but funded under RESAS   | James Hutton Institute              | East of Scotland Farm Survey   | <b>East Farm</b>   |

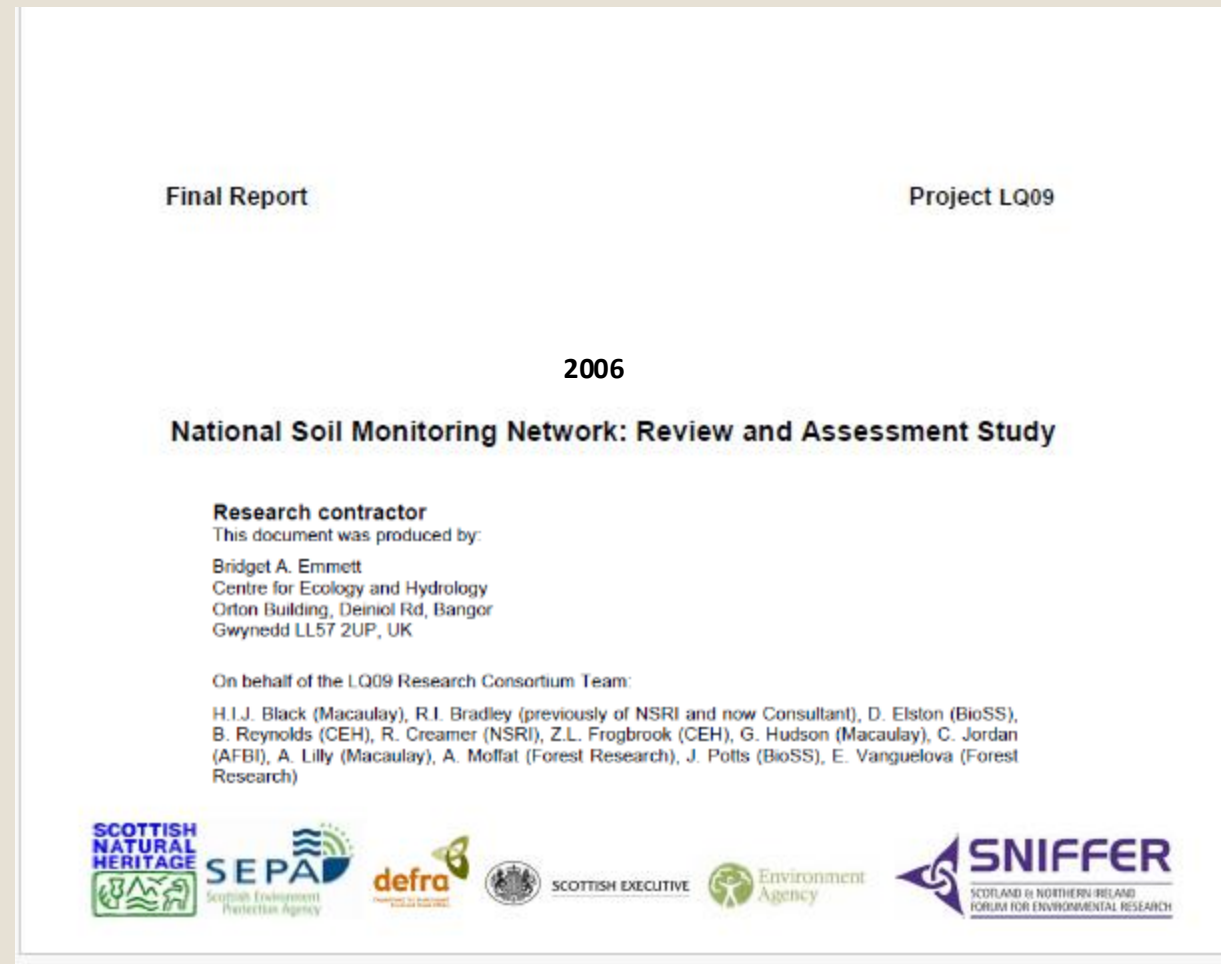
# Division of schemes

- Of a total these 17 schemes, 7 have funding and cover all habitats and soils nationally using a sampling design and number of samples to capture a national representative unbiased sample (EES in England, NSI in England and Wales, NSI in Scotland, ERAMMP in Wales, CS in Northern Ireland, CS in Great Britain and LUCAS in the EU)
- 3 schemes are large schemes with design to capture unbiased sample but target specific habitats:
  - Agriculture (SNHS/S)
  - Forestry (Biosoil & BioD/UK)
  - Non-arable soils (B&R survey/S)
- 5 schemes are networks based on 'typical' sites along gradients or to capture a range of vegetation or geological / soil classes
- None (5) in Scotland are currently active – work is ongoing to develop new schemes
- One (NSIE&W) in England and Wales with no current funding.
- LUCAS/EU assumed not to be continuing for the UK

**This leaves 9 active schemes in total with funding going forward currently**

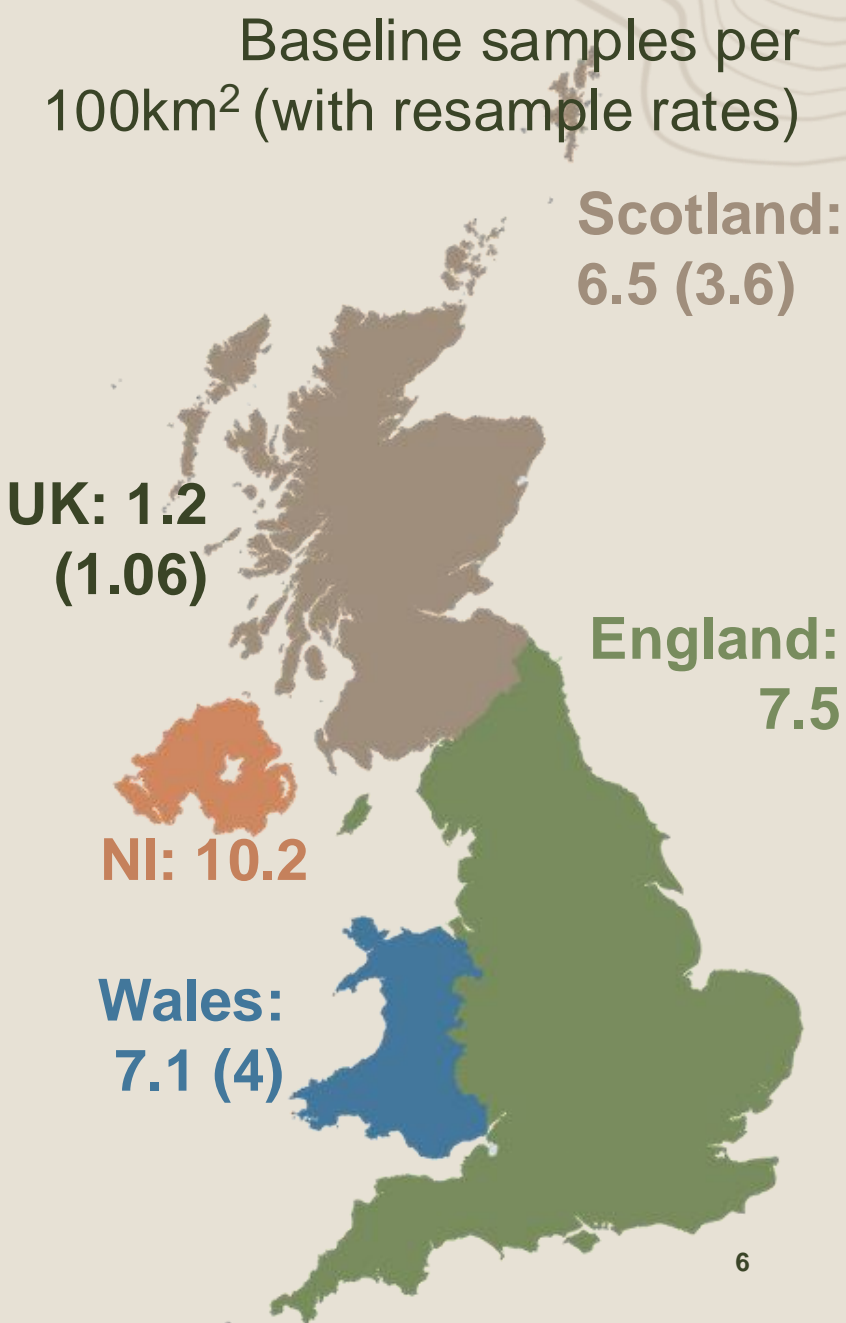
# There are many other soil monitoring programmes which have no specific funding in place but are a massive potential resource....

- NSI E&W (Cranfield) being the most obvious largest scheme
- 29 schemes were identified and reported in this report back in 2006 (Emmett et al. LQ09).
- There is a linked excel file database on specific design and indicators for each scheme....



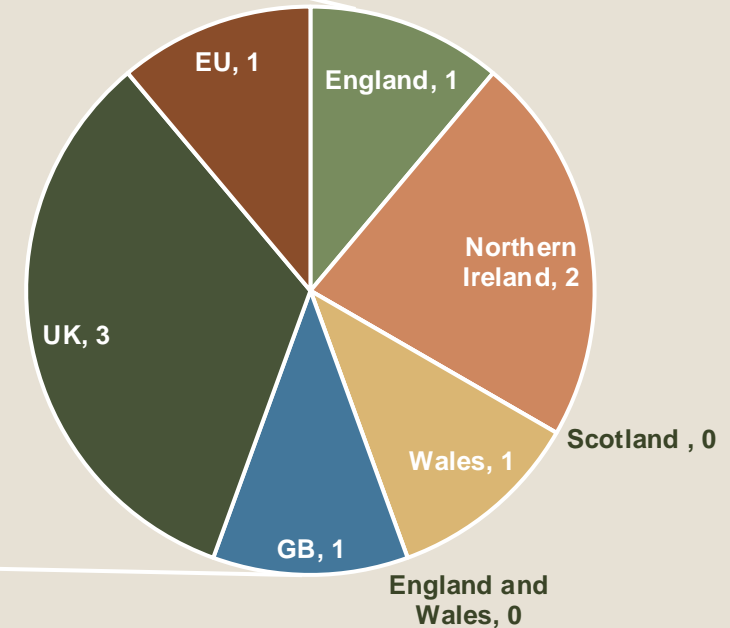
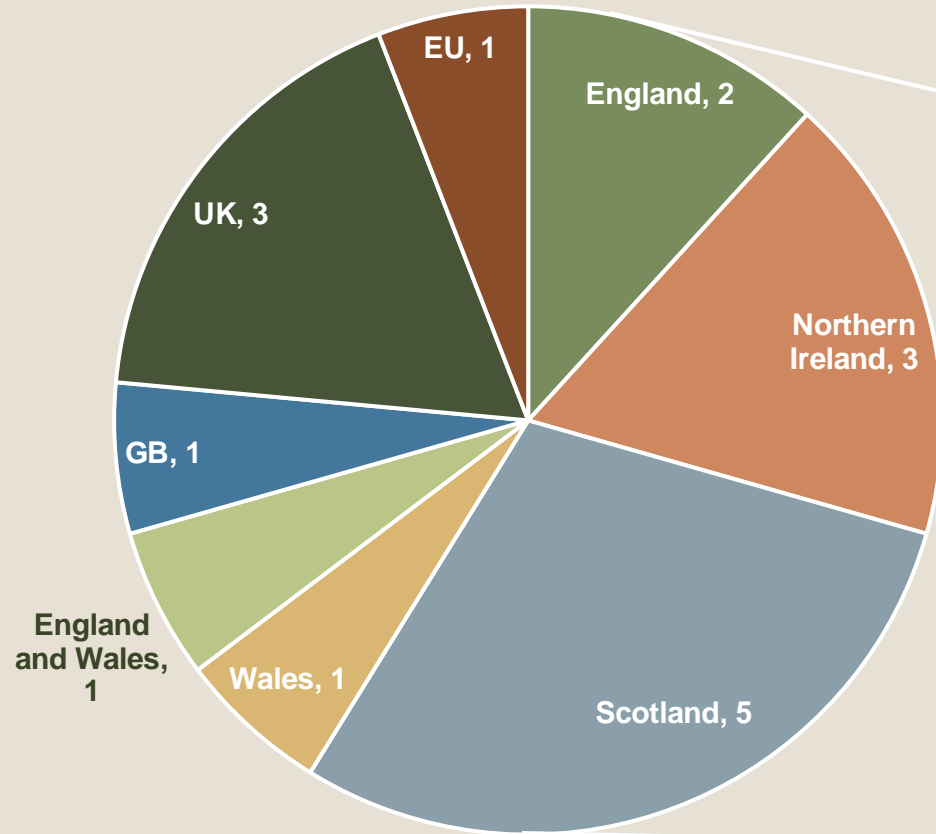
# Sampling rates for the 4 main national monitoring programmes

|   | England                     | NI                        | Scotland                         | Wales                                   | UK                          |
|---|-----------------------------|---------------------------|----------------------------------|---|-----------------------------|
| Current national monitoring scheme in place       | Yes (EES)                   | Yes (CSNI)                | No but in prep (NSIS previously) | Yes (ERAMMP)                            | Yes CS (+ CSNI makes it UK) |
| Change reporting period possible                  | None<br>2024-8 onwards only | None<br>2024 onwards only | 1978 onwards likely              | 2013 - 2023<br>(links to 1978 possible) | 1978 - 2026                 |
| Sample No. for baseline (and for repeat sampling) | 10,000                      | 1,440                     | 5222 (2848)                      | 1500 (840)                              | 2975 (2500)                 |
| Country area (000 km <sup>2</sup> )               | 133                         | 14                        | 80                               | 21                                      | 234                         |



# Number of monitoring schemes per nation (17)...

## ... with ongoing funding (9)



# Environmental priorities driving different monitoring schemes

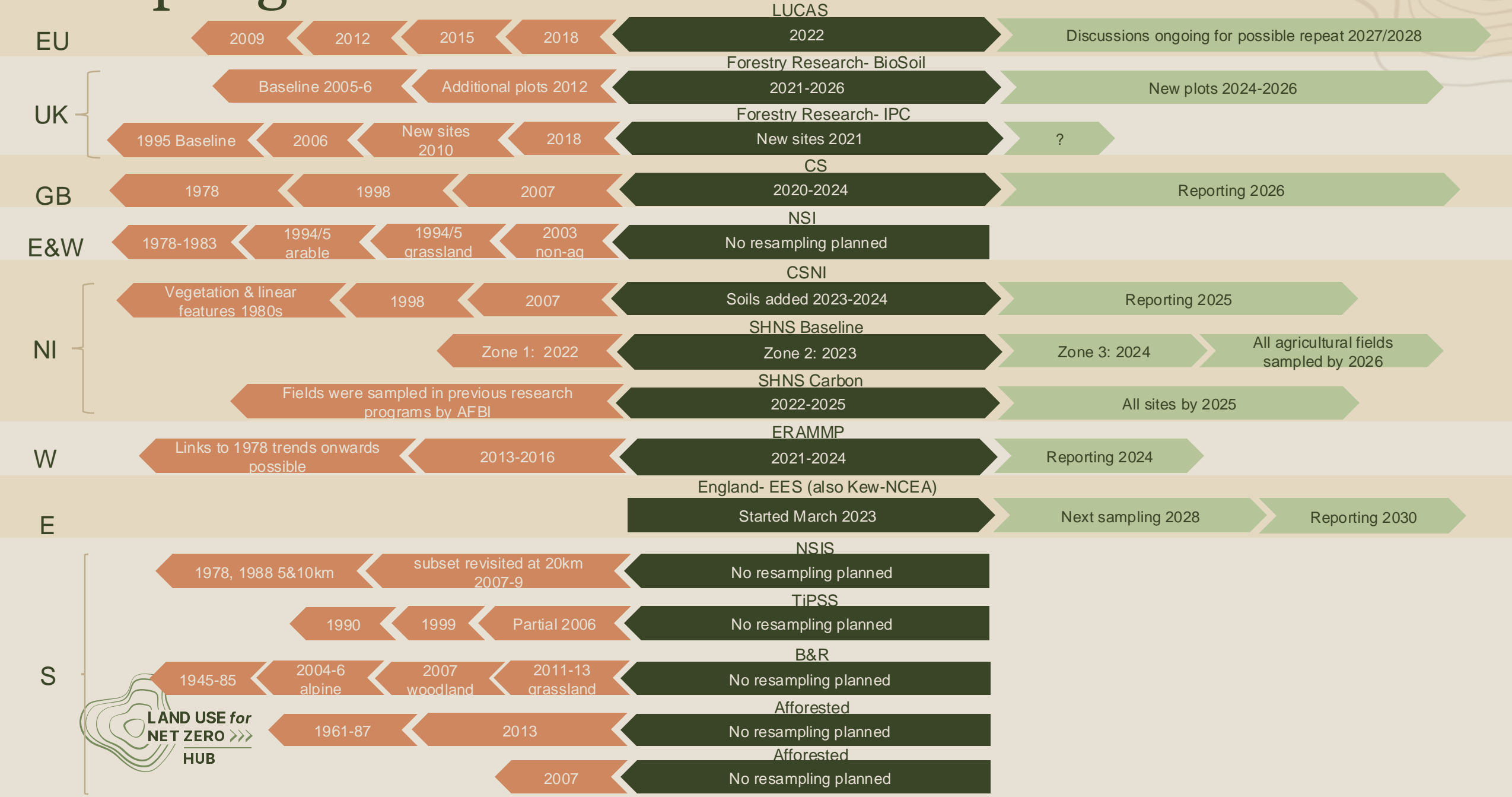
**6** schemes note water flow regulation, food quality habitat provision and pollution Control

**2** schemes note soil biodiversity value and general sustainable land management

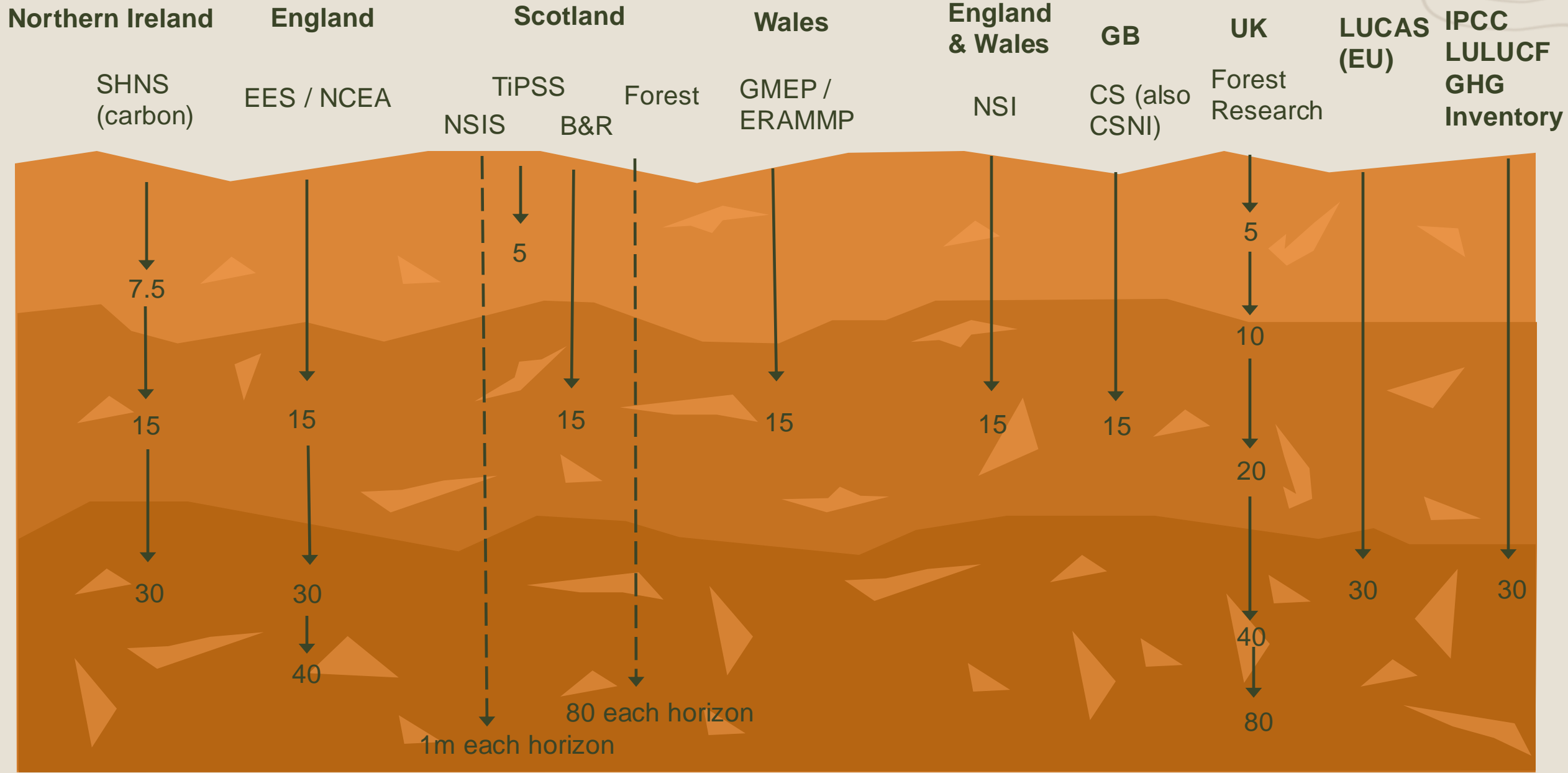
**7** schemes note water quality and nutrient provision

**11** schemes note carbon sequestration and climate

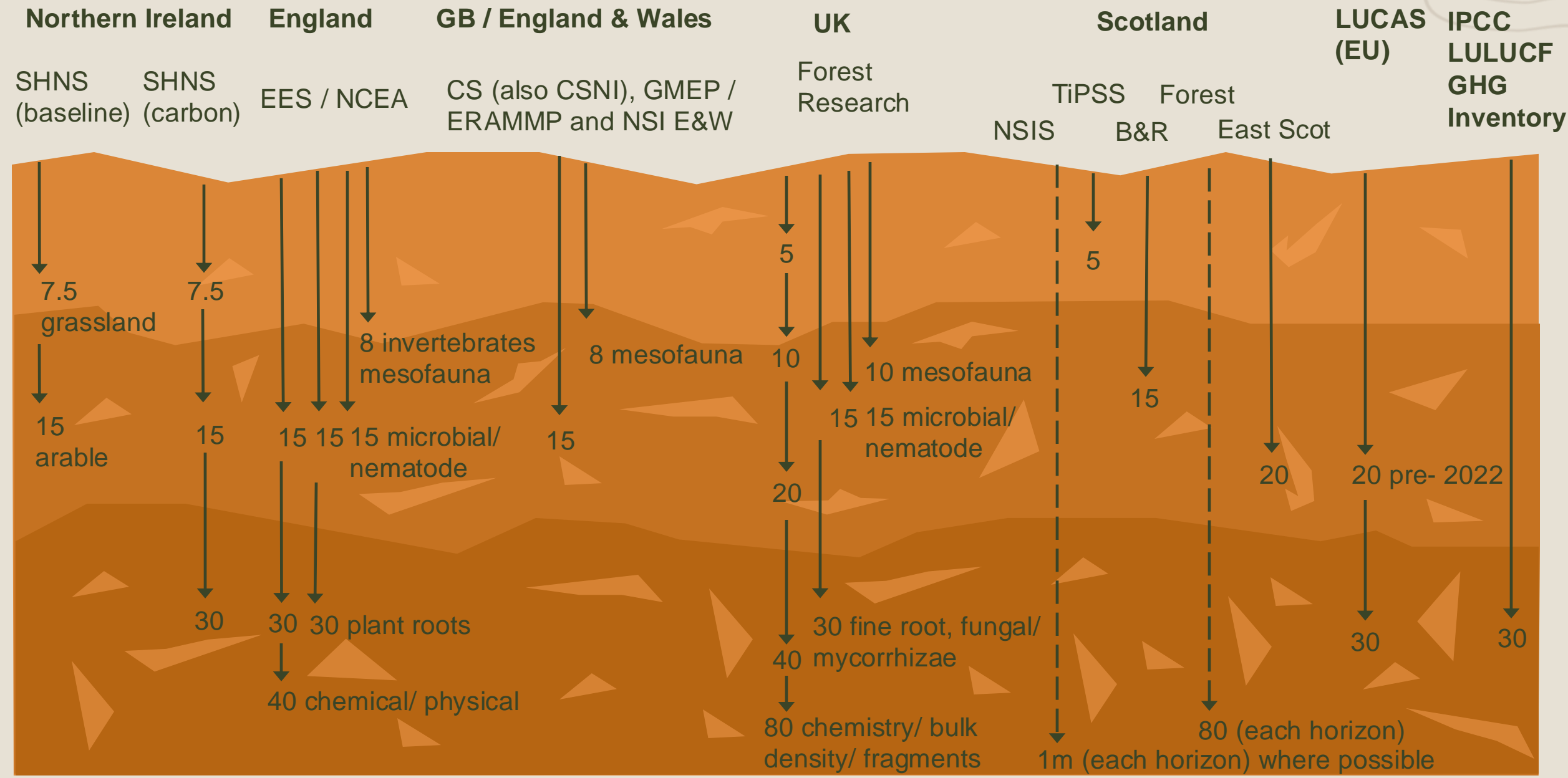
# Sampling timelines – detail of all schemes



# Sampling depths - organic matter



# Sampling depths – for variety of indicators



# Pollutants monitored

|                               | Northern Ireland |        |      | Scotland  |                                     |  |                   |           | England |          | Wales         | E/W     | GB        | UK                        | UK                        | UK         | EU                                   |
|-------------------------------|------------------|--------|------|-----------|-------------------------------------|--|-------------------|-----------|---------|----------|---------------|---------|-----------|---------------------------|---------------------------|------------|--------------------------------------|
| Scheme                        | SNHS             | SNHS-C | CSNI | NSIS      | TIPSS                               | R&B  | Afforested        | East Farm | EES     | Kew-NCEA | GMEP / ERAMMP | NSI E&W | CS        | FR BioSoil                | FR Level II               | FR Level I | LUCAS Soil                           |
| Plastics                      |                  |        |      | From 2007 |                                     |  |                   |           |         |          |               |         |           | Could on archived samples | Could on archived samples |            | 100 sample test                      |
| Pesticides                    |                  |        |      |           |                                     |  |                   |           |         |          |               |         |           |                           |                           |            | 3300 samples, 120 active ingredients |
| Persistent organic pollutants |                  |        |      |           | Organic Pollutants (PAH, PCB, PBDE) | Total and 16 individual PAHs; Total and 13 PCB congeners | Alpine sites only |           |         |          |               |         | 1998 only |                           |                           |            |                                      |
| Heavy metals                  |                  |        |      |           |                                     |  |                   |           |         |          |               |         | Yes       |                           |                           |            |                                      |

# Soil Biodiversity including eDNA

- MBC = Metabarcoding
- TF = Tullgren Funnels
- BF = Baermann Funnel

|                                  | Northern Ireland |                             |         | Scotland   |       |       |            |           | England   |                                 | Wales          | E/W     | GB                     | UK  | UK         | UK  | EU         |
|----------------------------------|------------------|-----------------------------|---------|--|-------|-------|------------|-----------|---|---------------------------------|----------------|---------|------------------------|---|------------|---|------------|
| Scheme                           | SNHS             | SNHS                        | CSNI    | NSIS   | TiPSS | R & B | Afforested | East Farm | EES   | Kew-NCEA                        | GMEP / ERAMMP  | NSI E&W | CS                     | FR BioSoil  | FR Level I | FR Level II   | LUCAS Soil |
| PLFA                             |                  | Yes                         |         | Yes  |       |       |            |           |   |                                 |                |         | 1998 only              |   |            |   |            |
| Microbial community              |                  | Yes                         |         | Yes (eDNA)   |       |       |            | Yes       | Yes, MBC  | Yes, root and fungal sequencing | GMEP only 2016 |         | Yes, MBC               | Yes, MBC  |            | Yes, MBC  | Yes, MBC   |
| Root associated mycorrhiza fungi |                  |                             |         | Yes  |       |       |            |           |   |                                 |                |         |                        |   |            |   |            |
| Functional genes / metagenomes   |                  | Yes                         |         | Yes  |       |       |            |           |   |                                 |                |         | Yes                    |   |            |   |            |
| Anti-microbial resistance        |                  |                             |         | Subsequent analyses  |       |       |            |           |   |                                 |                |         |                        |   |            |   | Yes        |
| Mesofauna                        |                  | Metagenomics bioinformatics | Yes, TF |  |       |       |            |           | Yes - TF and MBC with emphasis on springtails and mites               |                                 | GMEP only- TF  |         | 1998 and 2007 only- TF | Yes - TF and MBC with emphasis on springtails and mites               |            | Yes - TF and MBC with emphasis on springtails and mites               |            |
| Earthworms                       |                  | Yes                         |         |  |       |       |            |           | Yes, BF and MBC   |                                 |                |         |                        | Yes, BF and MBC   |            | Yes, BF and MBC   |            |
| Nematodes                        |                  |                             |         | Some sites sampled 1978-88 had Nematode populations identified |       |       |            |           | Yes, Morphological identification, fresh weight and ecological groups |                                 |                |         |                        | Yes, Morphological identification, fresh weight and ecological groups |            | Yes, Morphological identification, fresh weight and ecological groups |            |

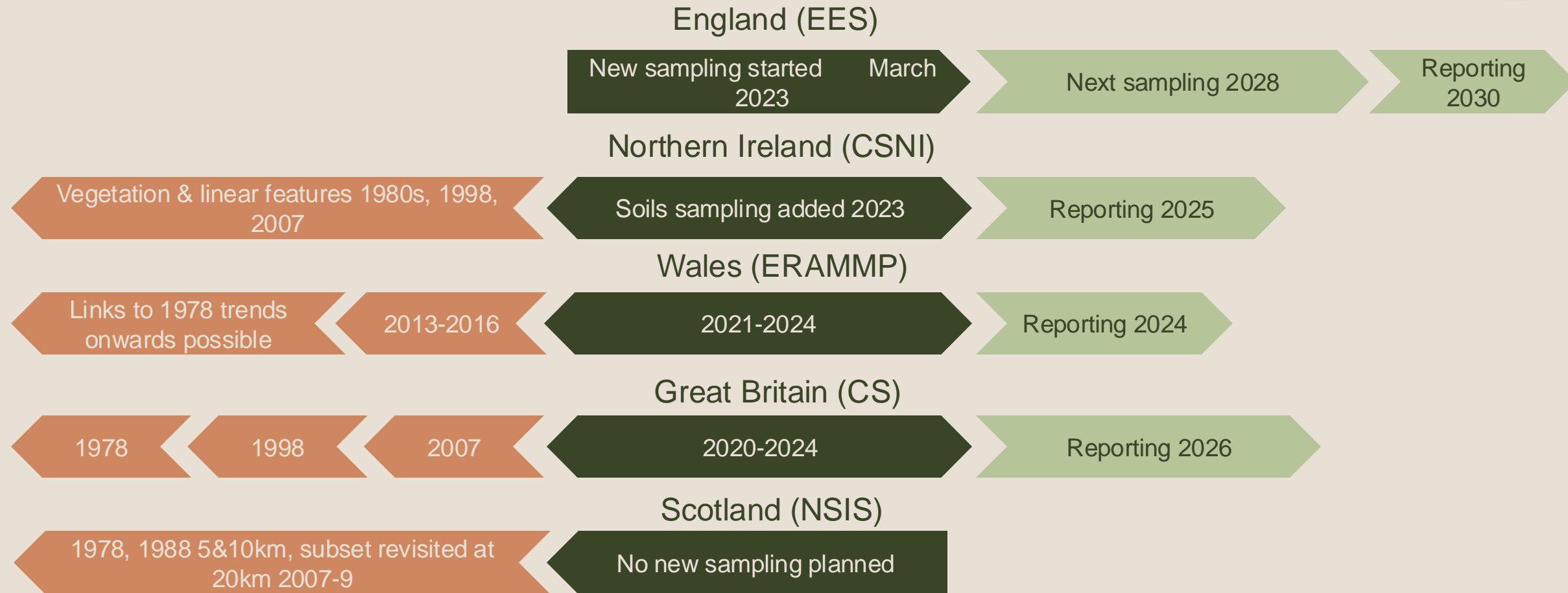
# Soil processes and functions

|                              | Northern Ireland |      |      | Scotland |       |       |            |           | England                 |          | Wales         | E/W    | GB        | UK         | UK         | UK                         | EU         |
|------------------------------|------------------|------|------|----------|-------|-------|------------|-----------|-------------------------|----------|---------------|--------|-----------|------------|------------|----------------------------|------------|
| Scheme                       | SNHS             | SNHS | CSNI | NSIS     | TiPSS | B & R | Afforested | East Farm | EES                     | Kew-NCEA | GMEP / ERAMMP | NSIE&W | CS        | FR BioSoil | FR Level I | FR Level II                | LUCAS Soil |
| Hot water extractable carbon |                  |      |      |          |       |       |            |           | Yes                     |          |               |        |           | Yes        |            | Yes                        |            |
| Potential N mineralisation   |                  |      |      | Yes      |       |       |            |           |                         |          |               |        | 2007 only | Some sites |            | Some sites                 |            |
| Basal respiration            |                  |      |      | Yes      |       |       |            |           |                         |          |               |        | 2007 only |            |            | Some sites, chamber method | Yes        |
| C substrate use              |                  |      |      |          |       |       |            |           | Yes, colormetric method |          |               |        | 2007 only |            |            |                            |            |

## SECTION 02

# Schemes with ongoing funding

# Sampling timelines - UK overview



# Sampling design

| Country                     | Scheme  | Sampling  |
|-----------------------------|---------|---|
| <b>All habitats / soils</b> |         |   |
| <b>England</b>              | EES     | Each monad will have one of the 21 soil classes (ITE/Institute of Terrestrial Ecology soil classes). 70% percent were randomly selected but with equal number of ITE soil classes. 30% of monads were selected by probability inclusion score (PI). 5 priority typologies to be covered by EES with probabilities: Broad habitats, priority habitats, landscape character types, HOST classes and NUTS1 (geographical regions). |
| <b>GB</b>                   | CS      | Stratified random sample of 1km squares according to land class but enhanced to allow for national reporting for the 4 nations.   |
| <b>NI</b>                   | CS      | Stratified random sample of 1km squares according to land class. In-line with GB Countryside Survey methods.  |
| <b>Wales</b>                | ERAMMP  | Stratified random sample of 1 km squares according to ITE land class, contains subset of CS squares.  |
| <b>EU</b>                   | LUCAS   | Stratified random sample according to land cover. Slight bias for agricultural land   |
| <b>Habitat specific</b>     |         |   |
| <b>UK</b>                   | BioSoil | Part of a EU forest soil and biodiversity survey with more 220 in the UK. Sites were selected on the basis of the presence of woodland of >0.5 ha on a 16 x 16 km national grid and covers a wide range of tree species and soil types.   |
| <b>NI</b>                   | SNHS    | All NI Agricultural land subject to voluntary participation from farm businesses (subset of min 250 sites across on different soil types specifically to model carbon dynamics)   |

# Approaches to interpretation frameworks

| Country                     | Scheme  | Soil identification  |
|-----------------------------|---------|--|
| <b>All habitats / soils</b> |         |  |
| <b>England</b>              | EES     | <p>Soil classification to Defra 12 soil groups, soil subgroup (Avery, 1980), and, where possible, soil series. Based on EES soil classification survey carried out according to Soil Survey Field Handbook (Hodgson, 2022).</p> <p>The soil classification survey (SC) is carried out on the same plots on which soil sampling and assessment (SSA) are carried out, alongside VESS.</p>   |
| <b>GB</b>                   | CS      | <p>1990 soil survey mapped at 1:25 000. Criteria used for mapping units in Scotland:</p> <p>Soil association - a group of soils developed on similar parent material</p> <p>Soil series - soils with a similar type and arrangement of horizons developed on similar parent material</p> <p>Criteria used for mapping units in England and Wales:</p> <p>Soil series - soils with a similar type and arrangement of horizons developed on similar parent material.</p> |
| <b>NI</b>                   | CS      | Full soil survey of Northern Ireland was conducted during the 1990s. Published as 1:50,000 and 1:250,000 soil maps and described by Cruickshank et al "Soil and Environment: Northern Ireland".  |
| <b>Wales</b>                | ERAMMP  | Not assessed?  |
| <b>EU</b>                   | LUCAS   | Not assessed?  |
| <b>Habitat specific</b>     |         |  |
| <b>UK</b>                   | BioSoil | Soil type described by England and Wales and Scottish national soil classification, also by World Reference Base 2016 classification and FC Forest Soil classification   |
| <b>NI</b>                   | SNHS    | Cruickshank et al. as above  |

# Methodology for SOM and SOC

| Country          | Scheme               | Depth                                       | Bulk density? | Soil organic matter method                         | Carbon fractions                 | Soil organic carbon |
|------------------|----------------------|---|---------------|--|----------------------------------|---------------------|
|                  | All habitats / soils |   |               |  |                                  |                     |
| England          | EES                  | Variable but 40cm max and 0-15cm available  | Yes           | TGA  | ?                                | Combustion          |
| GB               | CS                   | 0-15cm                                      | Yes           | LOI (375deg.C for 16 hours) until 2007 but now TGA | Subset of samples (POM and MAOM) | Combustion          |
| NI               | CS                   | 0-15cm                                      | Yes           | LOI (375deg.C for 16 hours)                        | ?                                | Combustion          |
| Wales            | ERAMMP               | 0-15cm                                      | Yes           | LOI (375deg.C for 16 hours) in 2016 now TGA        | ?                                | Combustion          |
| EU               | LUCAS                | 0-20cm previously but now 0-30cm but layers | Yes           | No   | Yes (POM and MAOM)               | Combustion          |
| Habitat specific |                      |   |               |  |                                  |                     |
| UK               | BioSoil              | Variable but 80cm max                       | Yes?          | LOI (375deg.C for 16 hours)                        | ?                                | Combustion          |
| NI               | SNHS                 | 7.5cm(grass); 15cm (arable)                 | No?           | No?  | ?                                | No?                 |

# Other variables

| Country              | Scheme  | pH                   | Nitrogen  | Phosphorus                                | Biodiversity   |
|----------------------|---------|----------------------|---|---|--|
| All habitats / soils |         |                      |   |   |  |
| England              | EES     | Yes (water)          | Total-N by combustion                               | Olsen-P and total-P                       | Metabarcoding (bacteria, fungi and mycorrhiza)   |
| GB                   | CS      | Yes (water and CaCl) | Total-N (previous mineralizable, extractable NO3-N) | Olsen-P (improved soils only) and total-P | Metabarcoding (bacteria, eukaryotic, fungi, AM, plant) on subset 2007; Metagenome (2020) |
| NI                   | CS      | Yes (water and CaCl) | Total-N by combustion                               | Olsen-P (improved soils only) and total-P | No   |
| Wales                | ERAMM P | Yes (water and CaCl) | Total-N by combustion                               | Olsen-P (improved soils only) and total-P | Metabarcoding (bacteria, fungi, eukaryotic) 2016 only                                    |
| EU                   | LUCAS   | Yes (water and CaCl) | Total-N by combustion                               | Olsen-P and total-P                       | Metabarcoding (bacteria and fungi)   |
| Habitat specific     |         |                      |   |   |  |
| UK                   | BioSoil | Yes (water and CaCl) | Total-N by combustion                               | Mehlich method and total-P                | Metabarcoding for bacteria, fungi and mycorrhiza, eukaryotes                             |
| NI                   | SNHS    | Yes                  | Total-N by combustion                               | Olsen-P                                   | Metabarcoding and metagenomes on subset  |

# Other infrequently measured variables in funded soil schemes



## Archiving



- CS (&CSNI), GMEP, ERAMMP, FR BioSoil, LUCAS, FR LVI&II, NSIS, TiPSS, B&R and Afforested all dry samples
- CS from 2019 (&CSNI), GMEP, ERAMMP, Kew NCEA, LUCAS and NSIS freeze samples
- *SHSN Freezes and dries, while SNHS (carbon) dries on 6 month temporary basis*
- Number of schemes are interested in exploring freezing



## Aggregate stability

- CS: Measured on ~ 400 samples from 2019 using conventional wet sieving and aggregate size distribution using the laser analyser.
- *(Was done for topsoils only in NSIS)*



## Peat Depth

- CS: 2019 onwards Peat rod for depth measured in 3 locations
- CSNI: 2023 & 2024 Peat rod for depth measured in 3 locations
- ERAMMP: 2021 onwards Peat rod for depth measured in 3 locations
- EES: Peat depth when thickness of organic horizon, if more than 2 cm thick
- FR BioSoil: Peat depth is measured by the depth sampling by coring, only down to 1m depth



## Erosion

- SHNS: Individual site assessment
- CSNI: Recorded via visual assessment at sampling plots
- *(NSIS: Erosion within 50m of the sample location was recorded)*



## Acoustics

- No schemes using so far



SUSTAINABLE  
**SOILS**  
ALLIANCE



UK Centre for  
Ecology & Hydrology

# Thank you

This resource was created from work undertaken by Prof. Bridget Emmett of the UK Centre for Ecology and Hydrology, and Ellen Fay from the Sustainable Soils Alliance, to understand soil monitoring initiatives across the four nations of the UK, including historical work by Prof. Emmett in this field.



UK Research  
and Innovation



Department  
for Environment  
Food & Rural Affairs



Department for  
Energy Security  
& Net Zero



Department for  
Science, Innovation,  
& Technology



Scottish Government  
Riaghaltas na h-Alba  
gov.scot