UKCEH Countryside Survey QA metadata and analysis report 2024 - EIDC

Topsoil physio-chemical data 2024

L. Bentley, S. Tandy, I. Lebron, M. Brentegani, A. Garbutt, C.M. Wood, D.A. Robinson

Client Ref: Internal Report
Issue number 1
28.August.2025

UK Centre for Ecology & Hydrology

Contents

1. UKCEH Countryside Survey Soil

Background information

Countryside Survey is a unique study or "audit" of the natural resources of the UK's countryside. The Survey has been carried out at regular intervals since 1978. The countryside is sampled and studied using rigorous scientific methods, allowing us to compare results from 2019+ with those from previous surveys. In this way, we can detect the gradual and subtle changes that occur in the countryside over time. A series of reports have been published outlining the main findings for UK and individual countries. The most recent report was based on monitoring in 2007 (Emmett et al., 2010) with components of the soils research published in Reynolds et al (2013) and Keith et al. (2020). A new monitoring cycle for 2019-2023 has now been completed following the adoption of a rolling program of monitoring in 2019 supported by NERC under the UK-SCAPE national capability program. The current monitoring cycle will extend from 2024-2028, supported by NERC under the NC-UK national capability program. It provides a science platform to address the overarching question:

What is the direction and magnitude of change in soil condition and function across the UK and how do multiple pressures interact to create the spatial and temporal patterns observed?

Soil health is fundamental for food security, public health and understanding the climate system. This national research platform addresses a critical gap in our understanding of soil status and dynamics at the national scale by transforming previous surveys since 1978 (Keith et al. 2020) through a new rolling sampling programme to provide data and maps of stock and change in GB soils, taking primary measurements of topsoil condition which influence soil function and with co-located vegetation assessments.

The survey is designed to address research questions of relevance to the UK and internationally, with a particular focus to determine the direction and magnitude of soil change. Some of the questions we hope to address include:

- How do multiple pressures interact to change topsoil and vegetation condition and function?
- How is the topsoil carbon pool changing in response to multiple pressures?
- Are topsoil carbon to nitrogen ratios changing across habitats?
- Is soil pH changing in response to reduced atmospheric pollution or changes in land management practices?
- Is there any evidence for increased compaction due to intensive management practices?

- Has improved land seen any change in the levels of available phosphorus?
- How does change in vegetation, driven by land use change or chemical deposition, feedback on topsoil condition and function?
- Has improved land seen any change in the levels of available phosphorus?
- How does change in vegetation, driven by land use change or chemical deposition, feedback on topsoil condition and function?

Introduction to the Countryside Survey Design and the rolling program

In the Countryside Survey, the monitoring survey was designed to 1) capture multiple measures and metrics for reporting at national scales (Scott, 2008; Reynolds 2013), and 2) support integration across these metrics and research into the drivers and interdependence of ecosystem changes. Hence, a full ecosystem-based approach is required where multiple indicators are captured at the same time in a single snapshot visit. The original monitoring program has been reduced and currently focuses on soil and vegetation change (vegetation data can be found in an accompanying data set).

The Countryside Survey is designed to capture a representative sample of the Great British countryside (therefore excluding marine and urban environments) at national and sub-national levels (GB and constituent countries) and uses a stratified random sample design. The strata used capture fundamental sources of ecological variation within the UK (including soil forming factors), that are largely static and consistent over time, including parent material, relief and climate (Bunce et al. 1996). Those strata are then sampled randomly and proportionally to strata land area, with more sampling units selected in the larger strata (although see below for exceptions to this prior to 2007 and how that is accounted for). The overall sample is considered to be representative of GB whilst ensuring that less common land classes are represented within the sample with greater sampling efficiency than a purely random sample can achieve (Robinson et al. 2024a). The sampling units used in CS are 1 km x 1 km squares corresponding to the British National Grid, with multiple plots established within each square to provide replication that are then revisited each monitoring cycle. Whilst replication at the square level is critical to the design, it is not with the intention of providing robust characterisation at the square level. Full replication, and therefore robust characterisation, is achieved at the strata level. The design has evolved over time with policy needs and computational capabilities, primarily to increase the total sample size of 1 km squares and increase the number of distinct strata, whilst maintaining the same core design principle and compatibility over time. A full record of changes to the survey design from 1978 to 2007 is provided in Barr & Wood (2011).

For UKCEH-CS, a rolling survey has now been adopted that will repeat once a five-year cycle or when ~500 squares have been completed. This is to identify change that occurs over that time period. The rolling programme is more practical and buffers

the results against extreme years in terms of climate fluctuations. It ensures we maximise the number of sites visited across the national spatial scale whilst at the same time monitoring year-on-year, such that spatial variation and temporal changes and trends can be detected cost-effectively. The current cycle starts in 2024.
A total of 500 x 1-km^2 squares, over the five-year cycle, were randomly sampled within strata defined according to the Land Classification of Great Britain (Bunce et. al., 2007) – a derived classification of the landscape based on its topography, geology, climate, and physical attributes. 100 of these squares will be visited on an annual basis.

The selection of the sample of 1km squares for monitoring is based on the Countryside Survey of Great Britain (as described below), which aims to provide robust estimates of indicators at national and sub-national level across GB and constituent countries. All squares selected in 1978 (256) form part of this resampling, then a selection of 1998 and 2007 squares. The rationale for selecting the 1978 squares was to give a repeat sampling over the longest period to identify change. The Countryside Survey design is covered in detail in the accompanying documentation.

A total of 500 x 1km squares, over the five-year cycle, were randomly selected for survey. These are stratified according to the Land Classification of Great Britain (Bunce et. al., 2007) – a statistically derived classification of the landscape based on its topography, geology, climate and physical attributes. Land classes are sampled by 1km squares proportionally to their area. Approximately 100 of these squares will be visited on an annual basis.

Any square randomly selected that contained more than 75% of urban land or that was more than 90% sea (defined by LCM2007 and the UK Census mean high tide data) was excluded.

To enable early reporting and analyses prior to the completion of a monitoring cycle and distribute the impacts of annual variation across the sample evenly, each annual set of 100 squares is selected to be a representative sub-sample of the 500, within practical limitations. In practice, we recommend the impact of using a less than complete monitoring cycle for analysis be investigated on a case-by-case basis to ensure the data remain appropriate for your application, with sufficient analytical power. Examples of this can be found in in papers published on the Countryside Survey Website (https://www.ceh.ac.uk/our-science/projects/countryside-survey).

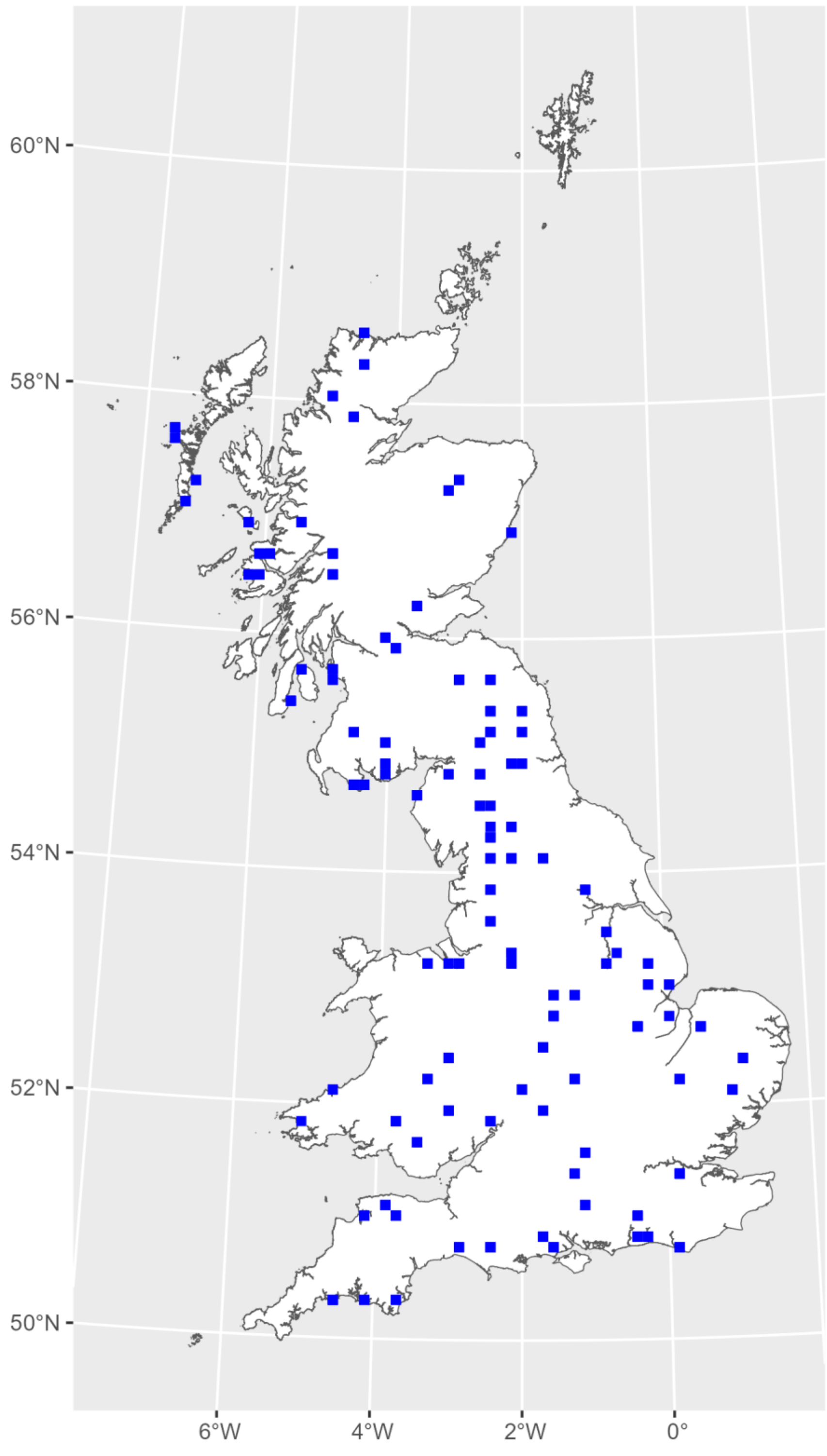

Figure 1. Map to show distribution of 1-km x 1-km survey squares across GB for 2024 (not shown to scale, to ensure data confidentiality).

Sample Collection Methods

Data were collected by trained field surveyors according to standard protocols set out in Robinson et al. (2024b) in the attached. Each field survey was carried out by teams of experienced surveyors and botanists, and was preceded by an intensive training course, ensuring high standards and consistency of methodology across CS according to criteria laid out in the field handbooks (Smart et al., 2024; Robinson et al., 2024b). During the surveys, survey teams were initially supervised and later monitored by experienced project staff in order to control data quality. This provides uniquely accurate and reliable information for soil monitoring and co-located plant and habitat information.

X plots

Within each 1-km x 1-km square, topsoil samples were taken from 5 pre-determined randomly dispersed locations (subject to landowner permissions and safe access in the field) within each 1km square, co-located with the vegetation survey X-Plots. The soil sample analysed for reported soil metrics is taken using a black plastic core, 15 cm long x 5cm diameter, from a location co-incident with vegetation surveys (Table 1). In addition, a second white 15cm x 5cm core is taken 15cm away from the Black core and stored as an air-dried sample in the UKCEH soil archive, and a third grey 15cm x 5cm core is also taken 15cm from the black core and stored as a frozen sample (-20°C) in the UCEH soil archive. After laboratory processing, any material remaining from the black core is also stored as a air-dried sample in the UKCEH soil archive.

The exact sampling location relative to the X plot has been varied slightly over time to ensure soil samples are not impacted by disturbance from previous sampling. This is primarily done by changing the corner of the 2x2m vegetation X plot the soil is sampled from (Table 1). Plots are relocated using detailed field maps, metal plates based in the corner of each plot and GPS readings. After field data collection, an analysis of exact plot locations is conducted to ensure plots were relocated accurately, using photos, field maps and GPS data.

Table 1. Location of sampling point in relation to 2 m x 2 m quadrat each year, Numbers of 1-km x 1-km squares visited, and numbers of squares attempted to visit, numbers of soil samples which were analysed.

Year	Location of sampling point -corner of 2 by 2m quadrat	Number of squares visited	Number of X plot soil samples analysed
1978	15 cm from South	256	1284
1998	15 cm from North	569	1284
2007	15 cm from South	591	2955

2018 2019	15 cm from West	6 100	25 456
2020	15 cm from West	48	196
2021	15 cm from West	110	493
2022	15 cm from West	110	464
2023	15 cm from West	149	597
2024	15cm from North	105	462

After collection, the topsoil cores are refrigerated and stored until posted, usually within a couple of days, to laboratories at the UK Centre for Ecology & Hydrology, Bangor. A summary of the processing of soil cores collected for X plots is provided in Figure 2.

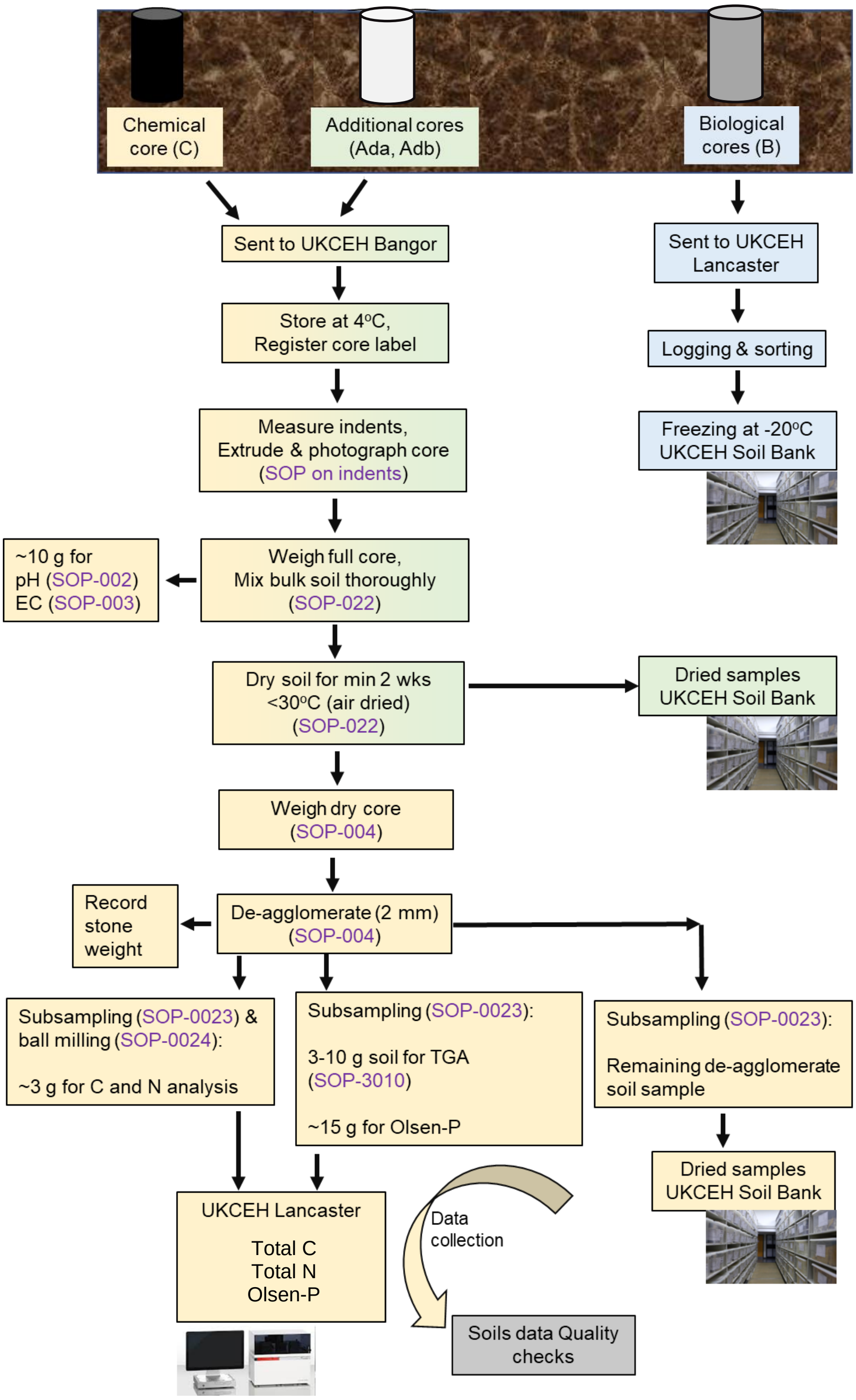

Figure 2: Soil core flow chart for 2024. Chemical cores are used for soil metric collection.

Linear plots

In the 2024-28 monitoring cycle, soil cores corresponding to linear features were collected for the first time. Linear features have been monitored for their botanical diversity under the Countryside Survey since 1984. Whilst X plots are a random sample of the environment within a square, linear plots target specific landscape features in proximity to a specific X plot. Three types of linear feature were surveyed for soils: Hedgerow plots (H plots), Boundary plots (B plots) and Streamside plots (S plots).

One linear feature of each type was selected from the linear features previously surveyed in the Countryside Survey vegetation monitoring from 50 of the 1km squares being surveyed for X plots per year. Squares that were part of the 1978 monitoring populations were prioritised to provide the longest timeseries for linear vegetation monitoring. Within the squares, linear plots were chosen to be as close as possible to and X plot to support paired analyses and minimise the required landowner permissions.

Soil samples (15cm long x 5cm diameter) were taken from the centre of each 1m x 10m linear feature vegetation plot. Soil and Vegetation Handbooks available as supporting documents for the corresponding datasets in 2024 for a full description of field protocols. All linear features are relocated following the same principles as X plots described above. All linear soil cores were archived as air-dried samples in the UKCEH soil bank, after analysis.

Table 2. Location of sampling point in relation linear plot each year, Numbers of 1-km x 1-km squares visited for linear plot sampling numbers of soil samples which were analysed by linear plot type. H = Hedgerow plots; S = Streamside plots; B = Boundary plots.

Year	Linear plot type	Location of sampling point	Number of squares surveyed for linear plots	Number of squares with plot type	Number of soil samples analysed
2024	H	Centre	49	21	21
2024	S	Centre	49	40	40
2024	B	Centre	49	35	35

Metrics, Laboratory Protocols and Analytical Methods

File details:

The dataset consists of one file containing information on plot identity, key environmental properties and soil metrics. Columns found in the file are listed below; refer to Robinson et al., 2024b and Emmett et al. 2008 for further details. Additional metrics for co-located vegetation data from 2024 can be found on the EIDC and identified with the same plot ID.

Soil sampling locations and general information
SQUARE; PLOT; PLOT_TYPE; COUNTRY; YEAR

Long-term countryside survey locations are identified using 1-km x 1-km square IDs (SQUARE). Within each square, up to five locations are surveyed for plants and sampled for soils (PLOT). If plots are considered lot a new plot may be established for the square, introducing a new PLOT relative to previous surveys. In addition, if a plot was not accurately relocation a new PLOT may be assigned. PLOT_TYPE denotes the plot type (X, H, B, S) from which soil samples were collected. These identifiers (SQUARE, PLOT, PLOT_TYPE) are used for all corresponding vegetation information, collected at the same plot and same time, published to the EIDC. COUNTRY defines the location of each SQ_ID within each of the three countries across Great Britain: England (ENG), Scotland (SCO) and Wales (WAL). YEAR defines the year of soil sampling.

Land Class
LC07, LC07_NUM

ITE Land Class 2007 of Great Britain is used as the basis for stratifying the survey (Table 2). Land classes are based on the major environmental gradients (climate, relief, geology) across the countryside (Bunce et al. 2007). The strength of Countryside survey is the ability to report changes in soil condition according to vegetation classes, either through broad habitat or aggregate vegetation class in 45 ITE land classes.

Table 2: ITE Land Classes (2007) as described in Bunce et al. 2007; LC07_NUM is the numeric equivalent to the 2007 Land Class description (LC07).

LC07_NUM	Country	Description (LC07)
1e	England	Flood plains/shallow valleys, S England
2e		Low calcareous hills / variable lowlands, S England
3e		Flat / gently undulating plains, E Anglia / S England
4e		Flat coastal plains, E Anglia / S England
5e		Shallow slopes / floodplains, S-W England
6e		Complex valley systems / table lands, S-W England

7e		Sea cliffs / hard coast, England
8e		Estuarine / soft coast / tidal rivers, England
9e		Almost flat plains, N Midlands, NE England
10e		Gently rolling / almost flat plains, NE England / N Midlands
11e		Flat plains / small river floodplains, E Midlands
12e		Large river floodplains, flat plains, margins, E Anglia
13e		Coastal plains / gently rolling low hills, NW England
15e		Flat river valleys / lower hill slopes, NW England
16e		Gently rolling low hills / flat river valleys, NW England
17e		Upland valleys / rounded hill sides, England
18e		Upland valley sides / Low mountains, N England
19e		Upland valleys / plateaux, N England
22e		Intermediate mountain tops / broad ridges, N England
23e		High mountain summits / ridges, N England
25e		Flat / gently undulating river valleys, N England
7s	Scotland	Hard / mixed coasts, S-W Scotland
13s		Coastal plains / soft coasts, S-W Scotland
18s		Isolated hills / mountain summits, W Scotland
19s		Upland valleys / low mountains, S Scotland
21s		Low mountain slopes / upper river valleys, Highlands
22s		Round mountains / broad upper ridges, S Scotland / Highlands
23s		High mountain summits / ridges / valleys, Highlands
24s		Steep valley sides / intermediate mountain tops, W Highlands
25s		Undulating plains / gently sloping valleys, E Scotland
26s		Flat plains / gently sloping lowlands, central & S Scotland

27s		Low hills / undulating lowlands, Scotland except W
28s		Shallow valleys / low hill plateaux, throughout Scotland
29s		Inner rocky / mixed coasts / complex topography, W Scotland
30s		Outer rockery / mixed coasts / low hills, W Scotland / Islands
31s		Rocky / mixed coasts / low hills, N Scotland / Islands
32s		Shallow hills / complex coastlines, N Scotland / Islands
17w1	Wales	Low mountain ridges / valley slopes, N Wales
17w2		Rounded mountains / scarps / upper valleys, mid / S Wales
17w3		Variable landforms of hills / low mountain, Wales
5w		Shallow slopes / flood plains, Wales
6w		Complex valley systems / table lands, Wales
7w		Sea cliffs / hard coast, Wales
15w		Flat river valleys / lower hill slopes, Wales
18w		Upland valley sides / low mountains, Wales

Countryside survey Environmental Zones
EZ_DESC_07

Environmental Zones are aggregations of ITE Land Classes (Table 3); these classes are derived from repeatable multivariate analysis of environmental data collected for each 1-km x 1-km square across GB. Thus, the classes, and hence the zones, are determined by combinations of environmental characteristics, not by just one or two. This means that the naming of classes (and zones) is not straightforward and cannot be achieved by reference to single parameters such as altitude (UKCEH Environmental Zones, 2013). Environmental Zone names were derived from an analysis of their average environmental characteristics and are namely:

Table 3: Environmental Zone categorization based on ITE Land Classes (2007).

Environmental Zone 2007	ITE Land Class Numbers (2007)	Environment Zone 2007 description
EZ1	11e, 12e, 25e, 2e, 3e, 4e, 9e	Easterly Lowlands, England

EZ2	10e, 13e, 15e, 16e, 1e, 5e, 6e, 7e, 8e	Westerly Lowlands, England
EZ3	17e, 18e, 19e, 22e, 23e	Uplands, England
EZ4	13s, 25s, 26s, 27s, 7s	Lowlands, Scotland
EZ5	18s, 19s, 28s, 29s, 30s, 31s, 32s	Intermediate Uplands and Isles, Scotland
EZ6	21s, 22s, 23s, 24s	True Uplands, Scotland
EZ7		(Northern Ireland, not included in this dataset)
EZ8	15w, 5w, 6w, 7w	Lowlands, Wales
EZ9	17w1, 17w2, 17w3, 18w	Uplands, Wales

UKCEH-CS soil carbon groups
SOIL_GROUP

Soils groups aggregated according to levels of soil organic matter (LOI) determined by loss on ignition are presented in the Table 4.

Table 4. Soil groups based on Loss-on-Ignition measurements.

Soil_GROUP	LOI category
Mineral	0 - >8% LOI (0-44 g C kg^{-1})
Humus mineral	8 – >30% LOI (44-165 g C kg^{-1})
Organo-mineral	30 – >60% LOI (165-330 g C kg^{-1})
Organic	60 – 100% LOI (>330 g C kg^{-1})

Broad Habitat Classification
BAP Broad Habitat (Jackson, 2000) recorded at the site of the plot, covering a minimum area of $400m^2$ (the minimum mappable unit, see Smart et al. 2024) to correspond with historic habitat mapping data collected by the Countryside Survey.

Measured and derived soil metrics

All soil cores were sent to UKCEH laboratories. Cores were logged into the laboratory system. Soil metrics may be measured on bulk soil (pH, moisture) or on Fine Earth

(FE). Basic measurements are carried out in the labs and include actual soil core length by measuring the indents at the top and the bottom of the soil core.

The associated soil volume including stones is then calculated as:

SOILCORE_VOLUMECM3_CS2007 =
$\pi \times 2.5^2 \times$ SOILCORE_LENGTH (cm)

The volume of the fine earth fraction without the volume of stones is calculated assuming the mass of stones in the soil core with a particle density of stones of 2.65 g cm^{-3}.

Soil pH in deionized water
PH

Soil pH measurements are carried out on a suspension of fresh field-moist bulk soil in deionised water. This method is the one employed by the Soil Survey of England and Wales (Avery and Bascomb, 1974).

Quality Control
Two different internal standards of known pH values were included in each batch. Readings were acceptable only when the measured pH for the internal standards varied within ± 2 standard deviations of the mean value. We included in each batch a suitable number of duplicated samples (about 10% of repetitions).

Loss-on-Ignition (LOI) and derived carbon concentration
LOI; C_CONC_LOI; C_STOCK_LOI

Samples were loaded into a ThermoGravimetric Analyser (LECO TGA701) and heated from 25°C to 1000°C in four steps. The first step is when the furnace reaches 105°C, at that point the temperature is kept constant for 3 h. In the second step, samples are heated to 375°C and sustained at a constant temperature for a total of 15.45 h, the weight loss between 105°C and 375°C gives the Soil organic matter content as Loss-on-Ignition (LOI):

LOI (g per 100g, %) = 100*(TGA_105-TGA_375)/(TGA_105)

Soil carbon concentration in g C per kg soil of soil is derived from the LOI measurement and is determined by:

C_CONC_LOI (g C per kg) =
0.55 * C_FE_LOI * 10

C_STOCK_LOI (t C per ha) =

$$(((0.15*10000)*(BULK\_DENSITY*1000))*C\_CONC\_LOI)/1000000$$

Units and conversions:

- 0.15 m for a representative depth for a core
- Area of 1 ha = 10000 m^2
- Bulk density converted to kg m^{-3} by multiplying by 1000
- Conversion of g C to t C by dividing by 1000000

Quality Control
LOI quality control checks were carried out using internal soil standards prepared in an identical manner to the sampled soils, also a sample of pure calcite was run with each run. Two different internal standards were included in each sample batch. Batches were repeated for which the measured LOI for the internal standards varied by more than 2 standard deviations in either direction from the mean value generated historically for the internal standards.

Soil bulk density, stones & porosity of fine earth
BULK_DENSITY

The bulk density of soil depends greatly on the mineral make up of soil and the degree of compaction. The particle density of quartz is around 2.65 g cm^{-3} but the (dry) bulk density of a mineral soil is normally about half that density, between 1.0 and 1.6 g cm^{-3}. Soils high in organics and some friable clay may have a bulk density well below 1 g cm^{-3}. Bulk density is a measure of the amount of soil per unit volume. It is therefore an excellent measure of available pore space in a soil and gives information on the physical status of the soil. Bulk density values are also essential when estimating soil carbon stocks, as they allow a conversion from %C to carbon per unit volume. Bulk density is determined from the C-core, which is 15 cm long with a radius of 2.5 cm.

The mass and volume of stones are derived from the total mass of stones in the measured subsample. Dry bulk density is calculated using the following equation:

$$\textbf{BULK\_DENSITY}\ (\text{dry, g cm}^{-3}) = \frac{\text{Dry weight core (105°C) (g) - stone weight (g)}}{\text{Core volume (cm}^{-3}\text{) - stone volume (cm}^{-3}\text{)}}$$

Fine earth volumetric and gravimetric water content when sampled
MOISTURE; *MOISTURE_DRY*

The gravimetric water content (GWC) was measured as i) g water per g oven dry soil (***MOISTURE_DRY***) and ii) g water per g wet soil (***MOISTURE***).

Quality Control
Quality control is achieved by using fix volume pre-cut sleeves for soil sampling and extensive training for soil surveyors.

Soil Olsen-phosphorous
PO4_OLSEN

Olsen-P was measured for soils from improved land (arable and improved grassland) only (***PO4_OLSEN***).

Briefly, 2 g of air- dried soil samples were extracted in 40 mL Olsen's reagent (0.5 M $NaHCO_3$ at pH 8.5) for 30 min in a mechanical end-over-end shaker. The sample was then filtered through a Whatman 44 filter paper to separate the soil and the filtrate; the filtrate was kept for analysis.

The analysis was performed on a Seal Analytical AA3 segmented flow analyser. For this type of analysis samples are mixed in the flow channel with acidic ammonium molybdate and potassium antimony tartrate to form a complex with phosphate. This complex is reduced with ascorbic acid to develop a molybdenum blue colour. The reaction is temperature controlled to 40°C using a water bath to ensure uniform colour development. The developed colour is measured at 880 nm.

Olsen-P concentrations (mg kg^{-1}) are calculated using a calibration curve, the mean of two extraction blanks is used to correct the data set and corrected for moisture content. The calibration range of this method is 0-5 mg L^{-1} phosphorus.

Quality Control
Two quality control reference samples, a duplicate sample and two blanks are run every 25 samples to ensure data quality. The final concentration is expressed mg kg^{-1} and it has been corrected for moisture content, the concentration of the blank and using a calibration curve of the standard.

Total soil nitrogen
N_PERCENT; N_STOCK

Total soil nitrogen (***N_PERCENT***) was measured ***for X plots only***, using the UKAS accredited method SOP3102, in UKCEH Lancaster. Samples were analysed using an Elementar Vario-EL elemental analyser (Elementaranalysensysteme GmbH, Hanau, Germany). The Vario EL is a fully automated analytical instrument working on the principle of oxidative combustion followed by thermal conductivity detection. Following combustion in the presence of excess oxygen the oxides of nitrogen flow through a reduction column which removes excess oxygen. Carbon is trapped on a column whilst nitrogen is carried to a detector.

This analysis was carried out on ball milled soil samples. Samples were oven dried at 105°C (± 5°C) for a minimum of 3 h, cooled and sealed prior to weighing. The sample was weighed into a tin cup (10-20 mg ball milled sample for soil) on a 6-place micro-balance. The results are expressed in % notation. ***N_STOCK*** (t N per ha) was calculated in the same was as C_STOCK_LOI (see above).

Quality Control
Quality control is achieved by use of two in-house reference materials analysed with each batch of ~20 samples. The instrument's calibration was checked on use using a working standard (Acetanilide) with a concentration of 10.4 % total nitrogen, and the sample data corrected (factored) against this value. Two of these standards were analysed at the beginning of every run, with every ten samples and again at the end of the run.

Data Quality Assurance

Soil data collection and processing for UKCEHs large-scale field surveys has undergone major scrutiny. With the change from one-year highly intensive surveying to rolling surveys, data collection and processing is more continuous. It requires a robust system to check, and Quality Assure (QA) data on a regular basis. UKCEH laboratory staff and data scientists developed a data workflow to ensure the highest possible soil data standard using R-scripts and guidance documents.

Details of data structure

The dataset (Table 5) consists of 20 columns and 559 rows. In the dataset, values of *-9999* denote missing samples.

Table 5. Meta data summary for topsoil data 2024.

COLUMN NAME	TYPE	UNIT	DESCRIPTION
SQUARE	Text	None	1-km survey square - unique identifier
PLOT	Number	None	Plot number for the soil sampling plot
PLOT_TYPE	Text	None	Plot type soil was samples for (X, H, S, or B)
YEAR	Number	None	Year of survey
BROAD_HABITAT	Text	None	BAP Broad Habitat (Jackson, 2000) recorded at the site of the plot, covering a minimum area of 400m^2 to correspond with historic habitat mapping data collected by the Countryside Survey.
PH	Number	None	Soil pH in water measured on field-moist bulk soil (B)

LOI	Number	g LOI / 100 g of oven dry soil; %	Soil organic matter content of fine earth (FE) as measured by Loss-on-Ignition
C_CONC_LOI	Derived number	g C / kg of oven dry soil	Soil carbon concentration of fine earth (FE, 0-15 cm)
C_STOCK_LOI	Derived number	t C / ha	Carbon density of fine earth (FE, 0-15 cm)
SOIL_GROUP	Category	None	UKCEH-Countryside Survey Carbon groups used in 2007 based on the levels of LOI
BULK_DENSITY	Number	g soil / cm^3	Soil bulk density (0-15 cm) of fine earth (FE, excluding stones)
MOISTURE	Number	g water/g of field moist soil	Gravimetric water content of the fine earth fraction per wet weight of soil
MOISTURE_DRY	Number	g water/g of oven dry soil	Gravimetric water content of the fine earth fraction per dry weight of soil
N_PERCENT	Number	g N / 100 g of oven dry soil; %	Total soil nitrogen content of fine earth (FE, 0-15 cm)
N_STOCK	Derived number	t N / ha	Total soil nitrogen content of fine earth (FE, 0-15 cm)
PO4_OLSEN	Number	mg P / kg of oven dry soil	Olsen-phosphorus of fine earth (FE, 0-15 cm); for arable and improved grassland soils only
LC07	Text	None	ITE Land Classification number - see Bunce et al. 2007
LC07_NUM	Number	None	ITE Land Classification number - see Bunce et al. 2007, ITE Land Class 2007 (numeric code)
COUNTRY	Category	None	GB country
EZ_DESC_07	Category	None	Countryside Survey Environmental Zone description; see: https://catalogue.ceh.ac.uk/documents/0cfd454a-d035-416c-80dc-803c65470ea2

2. References

Barr, C.J.; Wood, C.M. (2011) The Sampling Strategy for Countryside Survey (up to 2007). Revised and Updated from: '**The Sampling Strategy for Countryside Survey'**, C.J. Barr, September 1998. DETR CONTRACT No. CR0212. NERC/Centre for Ecology & Hydrology, 22pp. (CEH Project Number: C03259)

Bunce, R.G.H., Barr, C.J., Clarke, R.T., Howard, D.C. and Lane A.M.J. (1996) **Land classification for strategic ecological survey.** Journal of Environmental Management 47, 37-60

Emmett, B. A., Frogbrook, Z. L., Chamberlain, P. M., Griffiths, R, Pickup, R., Poskitt, J., Reynolds, B., Rowe, E., Rowland, P., Wilson, J., Wood, C. M.. 2008 **Countryside Survey. Soils Manual.** NERC/Centre for Ecology & Hydrology, 180pp. (CS Technical Report No.3/07, CEH Project Number: C03259) http://nora.nerc.ac.uk/5201/1/CS_UK_2007_TR3%5B1%5D.pdf

Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C.. 2010 **Countryside Survey: Soils Report from 2007**. NERC/Centre for Ecology and Hydrology, 192pp. (CS Technical Report No. 9/07, CEH Project Number: C03259)

Jackson, D. (2000). Guidance on the Interpretation of the Biodiversity Broad Habitat Classification (Terrestrial and Freshwater Types): **Definitions and the Relationship with Other Habitat Classifications (JNCC Report, No 307)** (Vol. Report no. 307, pp. 73pp). Published online.

Keith, A.M., Griffiths, R.I., Henrys, P.A., Hughes, S., Lebron, I., Maskell, L.C., Ogle, S.M., Robinson, D.A., Rowe, E.C., Smart, S.M. and Spurgeon, D., 2020. **Monitoring soil natural capital and ecosystem services by using large-scale survey data**. Soil ecosystems services, pp.127-155.

Robinson, D.A., Bentley, L., Jones, L., Feeney, C., Garbutt, A., Tandy, S., Lebron, I., Thomas, A., Reinsch, S., Norton, L., Maskell, L., Wood, C., Henrys, P., Jarvis, S., Smart, S., Keith, A., Seaton, F., Skates, J., Higgins, S., … Emmett, B. A. (2024a). **Five decades' experience of long-term soil monitoring, and key design principles, to assist the EU soil health mission.** European Journal of Soil Science, 75(5), e13570. https://doi.org/10.1111/ejss.13570

Robinson, D. A., Bentley L., Smart S., Wood. C, Garbutt A., Fitos E. (2024b) **UKCEH Countryside Survey: Soil Handbook 2024-2029 – Soil Cores.**

Reynolds, B., Chamberlain, P.M., Poskitt, J., Woods, C., Scott, W.A., Rowe, E.C., Robinson, D.A., Frogbrook, Z.L., Keith, A.M., Henrys, P.A. and Black, H.I.J., 2013. **Countryside Survey: National "Soil Change" 1978–2007 for Topsoils in Great Britain—acidity, carbon, and total nitrogen status**. Vadose Zone Journal, 12(2).

Scott W.A. 2008. **Statistical Report CS Technical Report No.4/07**, Centre for Ecology and Hydrology, (Natural Environment Research Council)

Smart, S. Maskell, L. Norton, L. Wood, C. Bunce, R., Barr, C. Patton, J. and Fitos, E. 2024. **UKCEH Countryside Survey: Field Handbook 2024-2029. Vegetation plots.**

3. Further Reading

Allen, S. E. 1989. **Chemical Analysis of Ecological Materials**, 2nd ed., Blackwell Scientific Publications.

Avery, B.W. and Bascomb, C.L. 1974. Soil Survey Laboratory Methods. **Soil Survey Technical Monograph No. 6,** Harpenden.

Avery, B.W., 1990. **Soils of the British Isles**. CAB International.

Black, H.I.J., Parekh, N.R., Chaplow, J.S., Monson, F., Watkins, J., Creamer, R., Potter, E.D., Poskitt, J.M., Rowland, P., Ainsworth, G. and Hornung, M., 2003. **Assessing soil biodiversity across Great Britain: national trends in the occurrence of heterotrophic bacteria and invertebrates in soil**. Journal of Environmental Management, 67(3), pp.255-266.

Bunce, R.G.H., Barr, C.J., Clarke, R.T., Howard, D.C. & Lane, A.M.J. (1996) **ITE Merlewood Land Classification of Great Bri**tain. Journal of Biogeography, 23, 625-634

Bunce, R.G.H., Barr, C.J., Whittaker, H.A. (1981), **Land Classes in Great Britain: Preliminary Descriptions for Users of the Merlewood Method of Land Classification**. Merlewood Research and Development Paper No. 86 http://nora.nerc.ac.uk/5898/1/R%26D0862.pdf

Bunce, R.G.H., Barr, C.J., Clarke, R.T., Howard, D.C., Scott, W.A. (2007). **ITE Land Classification of Great Britain 2007. NERC Environmental Information Data Centre**. http://doi.org/10.5285/5f0605e4-aa2a-48ab-b47c-bf5510823e8f

Carey, P.D., Wallis, S., Chamberlain, P.M., Cooper, A., Emmett, B.A., Maskell, L.C., McCann, T., Murphy, J., Norton, L.R., Reynolds, B., Scott, W.A., Simpson, I.C., Smart, S.M., Ullyett, J.M.. 2008 **Countryside Survey: UK Results from 2007. NERC**/Centre for Ecology & Hydrology, 105pp. (CEH Project Number: C03259).

Countryside Survey Website: General overview of Countryside Survey project with links to many relevant documents and methodologies.
http://www.countrysidesurvey.org.uk/

Griffiths, R.I., Thomson, B.C., James, P., Bell, T., Bailey, M. and Whiteley, A.S., 2011. **The bacterial biogeography of British soils**. Environmental microbiology, 13(6), pp.1642-1654.
https://sfamjournals.onlinelibrary.wiley.com/doi/full/10.1111/j.1462-2920.2011.02480.x

Jackson, M.L., 1958. **Soil Chemical Analysis**. Prentice Hall, London.

Norton, L.R., Maskell, L.C., Smart, S.S., Dunbar, M.J., Emmett, B.A., Carey, P.D., Williams, P., Crowe, A., Chandler, K., Scott, W.A. and Wood, C.M., 2012. Measuring stock and change in the GB countryside for policy–key findings and developments from the Countryside Survey 2007 field survey. Journal of environmental management, 113, pp.117-127.
https://nora.nerc.ac.uk/id/eprint/19534/1/N019534PP.pdf

PB13297, 2009. **Safeguarding our soils a strategy for England**, Defra, Nobel House, 17 Smith Square, London SW1P 3JR

Rowe, E.C., Emmett, B.A., Frogbrook, Z.L., Robinson, D.A. and Hughes, S., 2012. **Nitrogen deposition and climate effects on soil nitrogen availability: influences of habitat type and soil characteristics. Science of the Total Environment, 434, pp.62-70.** https://nora.nerc.ac.uk/id/eprint/16026/1/N016026PP.pdf

Ruehlmann, J., 2020. **Soil particle density as affected by soil texture and soil organic matter: 1. Partitioning of SOM in conceptional fractions and derivation of a variable SOC to SOM conversion factor**. Geoderma, p.114542.

Ruehlmann, J. and Körschens, M., 2020. **Soil particle density as affected by soil texture and soil organic matter: 2. Predicting the effect of the mineral composition of particle-size fractions.** Geoderma, p.114543.

UK Centre for Ecology & Hydrology, Countryside Survey Environmental Zones, 2013
https://catalogue.ceh.ac.uk/documents/0cfd454a-d035-416c-80dc-803c65470ea2

UKCEH Soil Bank (uksoilbank@ceh.ac.uk):
https://catalogue.ceh.ac.uk/documents/d5a7b276-3fbc-4d12-b816-0f74a4692a33

Contact

enquiries@ceh.ac.uk

@UK_CEH

ceh.ac.uk

Bangor

UK Centre for Ecology & Hydrology
Environment Centre Wales
Deiniol Road
Bangor
Gwynedd
LL57 2UW

+44 (0)1248 374500

Edinburgh

UK Centre for Ecology & Hydrology
Bush Estate
Penicuik
Midlothian
EH26 0QB

+44 (0)131 4454343

Lancaster

UK Centre for Ecology & Hydrology
Lancaster Environment Centre
Library Avenue
Bailrigg
Lancaster
LA1 4AP

+44 (0)1524 595800

Wallingford (Headquarters)

UK Centre for Ecology & Hydrology
Maclean Building
Benson Lane
Crowmarsh Gifford
Wallingford
Oxfordshire
OX10 8BB

+44 (0)1491 838800

UK Centre for Ecology & Hydrology