https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

UKCEH Countryside Survey state and change soil data for Great Britain, 1978-2023

Laura Bentley[1]*, Claire M. Wood[2], Chris Feeney[1], Sabine Reinsch[1], Angus Garbutt[1], Susan Tandy[1], Inma Lebron[1], Amy Thomas[1], Maud van Soest[1], Victor Ebuele[1], James Lucas[1], M. Gloria Pereira[1], Patrick Keenan[2], Joe D. Taylor[2], Briony Jones[1], Lindsay Maskell[2], Pete Henrys[2], Simon Smart[2], Bronwen Williams[1], Aidan M. Keith[2], Fiona Seaton[2], Lisa Norton[2] Bridget A. Emmett[1], David A. Robinson[1]

1) UK Centre for Ecology & Hydrology, Deiniol Road, Bangor LL57 2UW, UK.

2) UK Centre for Ecology & Hydrology, Library Avenue, Bailrigg, Lancaster. LA1 4AP, UK.

Correspondence to: Laura Bentley (lauben@ceh.ac.uk)

Abstract. The UKCEH Countryside Survey (CS) represents the longest ongoing integrated national monitoring program for the countryside of Great Britain (GB), providing policy relevant evidence on environmental condition. Through the use of a co-located sampling design across soils, vegetation, woodlands and waterbodies, the data offer a holistic insight into shifts in environmental condition, the drivers of change and the complex patterns that result across ecosystems, to address a variety of research questions. The soils component of CS is arguably one of the world's most enduring national-scale datasets on soil health, tracking state and change as part of this broader 'audit' of the GB countryside. The monitoring program has been active since 1978, with the latest complete monitoring cycle concluding in 2023 and a new monitoring cycle currently underway (2024-28). The primary aim of this paper is to compile and synthesise all published datasets pertaining to soil state and change, whilst bringing the dataset up to date by reporting on data from the latest cycle (2019-2023). The dataset comprises >8600 topsoil samples from 2,233 plots surveyed over nearly five decades. A comprehensive array of physico-chemical properties are regularly updated with each monitoring cycle, including pH, soil organic matter (SOM), soil organic carbon (SOC, concentration and stock), bulk density, gravimetric moisture content and nutrient loading, though nitrogen content (concentration and stock) and plant-available phosphorus (Olsen P). Nevertheless, numerous additional national baseline metrics have been established throughout the years to address specific policy and research inquiries, including indicators of pollution (heavy metals and organics), biodiversity measures such as invertebrate biodiversity and eDNA based biodiversity estimated for bacteria, fungi and plants, and supporting metrics that facilitate interpretation of soils data, such as texture via laser diffraction particle size analysis, total carbon and $CaCO_3$. Further datasets have been established through specific research queries and use of airdried and frozen soils in the UKCEH soil bank. Contextual data is supplied regarding habitat type, land management practices, and soil type, facilitating wider use of the dataset and subsampling according to need. The datasets have been widely used across over 200 publications and are available under an open government licence,

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

facilitating a unique evaluation of soil state and change over time, within the context of a suit of co-located habitat condition metrics from across Great Britain.

Copyright statement

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

1 Introduction

The UKCEH Countryside Survey (CS) has been providing national-scale information and data on the condition and evolution of soils in Great Britain (GB) since its establishment in 1978 (Bunce 1978; Robinson et al., 2025). This survey was groundbreaking in its design to monitor environmental changes across the wider countryside (i.e. to the exclusion of urban and marine environments) and has evolved over five decades of repeated field surveys to address both policy and scientific questions. The survey provides evidence on how various indicators of environmental condition, particularly soil in this paper, are changing over time at national and policy relevant scales (Emmett et al., 2007; Reynolds et al., 2013; Bentley et al., 2025). The monitoring framework was crafted to encompass multiple co-located measures and metrics in both time and space (Scott, 2008; Reynolds 2013) to facilitate an integrated understanding of condition and change. For the current CS, a rolling survey methodology has been implemented, which repeats every five years or upon the completion of 500 1km squares. The rolling program captures a more representative signal of climate impacts on the environment within a monitoring cycle, offers logistical benefits (e.g. a more stable surveyor skill base) and confers resilience to evolving stakeholder needs. It preserves the full statistical power of the complete monitoring cycle, whilst simultaneously allowing for agile early reporting for specific policy questions, and the detection of spatial and temporal trends in a cost-effective manner. As soil health ascends the international agenda, there is a growing emphasis on comprehending the state and change of soils over time. In Europe, this has recently led to the establishment of a soil monitoring law (Panagos et al. 2025), which seeks to align soil resource monitoring with that of freshwater and biodiversity. The Land Use and Cover Area frame Survey (LUCAS) monitoring program bolsters this initiative and has commenced assessing the state and changes in soils since 2009 (de Rosa et al. 2023; Ballabio et al. 2016). Although CS and LUCAS are independent monitoring programs, they share a common heritage. R.G.H. Bunce was pivotal in setting the vision for both, the national survey in the UK (Bunce and Shaw 1973; Bunce et al., 1996, Wood et al. 2025), which led to Countryside Survey, and for environmental monitoring across Europe (Metzger et al., 2005; Bunce et al., 2008) by supporting the development of LUCAS. In addition to aligning with EU monitoring, CS is unique in the UK in offering a continuous time-series over five decades, placing current and future soil conditions in a vital historical context, amidst growing pressures from climate change and changes in agri-environment policy in the last five years (HM Government, 2018; Emmett et al., 2025). The nationally representative sampling design and the temporal and spatial extent provide a unique power to address scientific questions across the broad environmental gradients present in GB, and more recently the UK with soil sampling now part of the Northern Ireland Countryside Survey, for a suite of integrated indicators.

This paper documents and synthesises the data produced so far, with greater focus given to recent additions to the dataset following the completion of the most recent monitoring cycle from 2019-2023. The paper contains references to 24 data sets, all published and released under the UK open government license (https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ [last accessed 24/04/2026]) produced from Countryside Survey soils monitoring.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



1 The Countryside Survey Design

The foundational design of the CS monitoring was predicated on a stratified-random sampling methodology to guarantee that the sample represented the entire nation whilst efficiently capturing the broad range of environmental variation present in GB (Barr & Wood, 2011; Robinson et al. 2025). Strata were established through a multivariate analysis of essential attributes that remain relatively stable, such as key soil forming factors including relief, parent material, and climate; these strata were referred to as land classes, discussed in the next section. The survey concentrated on systematically sampling vegetation and soils that were co-located, alongside other variables such as linear and freshwater features that have also been surveyed and reported on in the past (Carey et al., 2009). The rationale for co-location stemmed from the belief that the soil-plant system evolves in tandem, and this co-location offered enhanced integration capabilities to understand the drivers of change, alongside cost efficiency. The primary sampling unit was defined as 1-km x 1-km squares. Within each sampling unit, five randomly positioned soil and vegetation sampling sites were established to provide further replication (Figure A1, replicated from Robinson et al., 2024). The initial survey, conducted in 1978, focused on ecosystem monitoring (encompassing both soils and vegetation) across a sample of 256 1-km squares throughout GB, utilizing eight 1-km squares per stratum. In 1998, soils were re-sampled, and the number of squares increased to 569 of which 256 were sampled for soils; by 2007, 591 1-km squares were sampled, with each land class sampled proportionally to its area. In 2019, the design evolved into a rolling program to capture natural inter-annual variability and streamline the logistics of the monitoring program. Approximately 100 squares have been sampled each year of the rolling survey (with exception of the period during the COVID-19 pandemic), with a total of ~500 squares completing a monitoring cycle over a five-year period, also distributed proportionally to land class area. Additional detail on the sampling design and principles behind the design of the CS soil monitoring is provided in Appendix A, with additional information on the collaboration with ERAMMP in 2019-23 in Appendix C. The latest completed cycle was conducted over 2019-2023, with a new cycle beginning in 2024.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

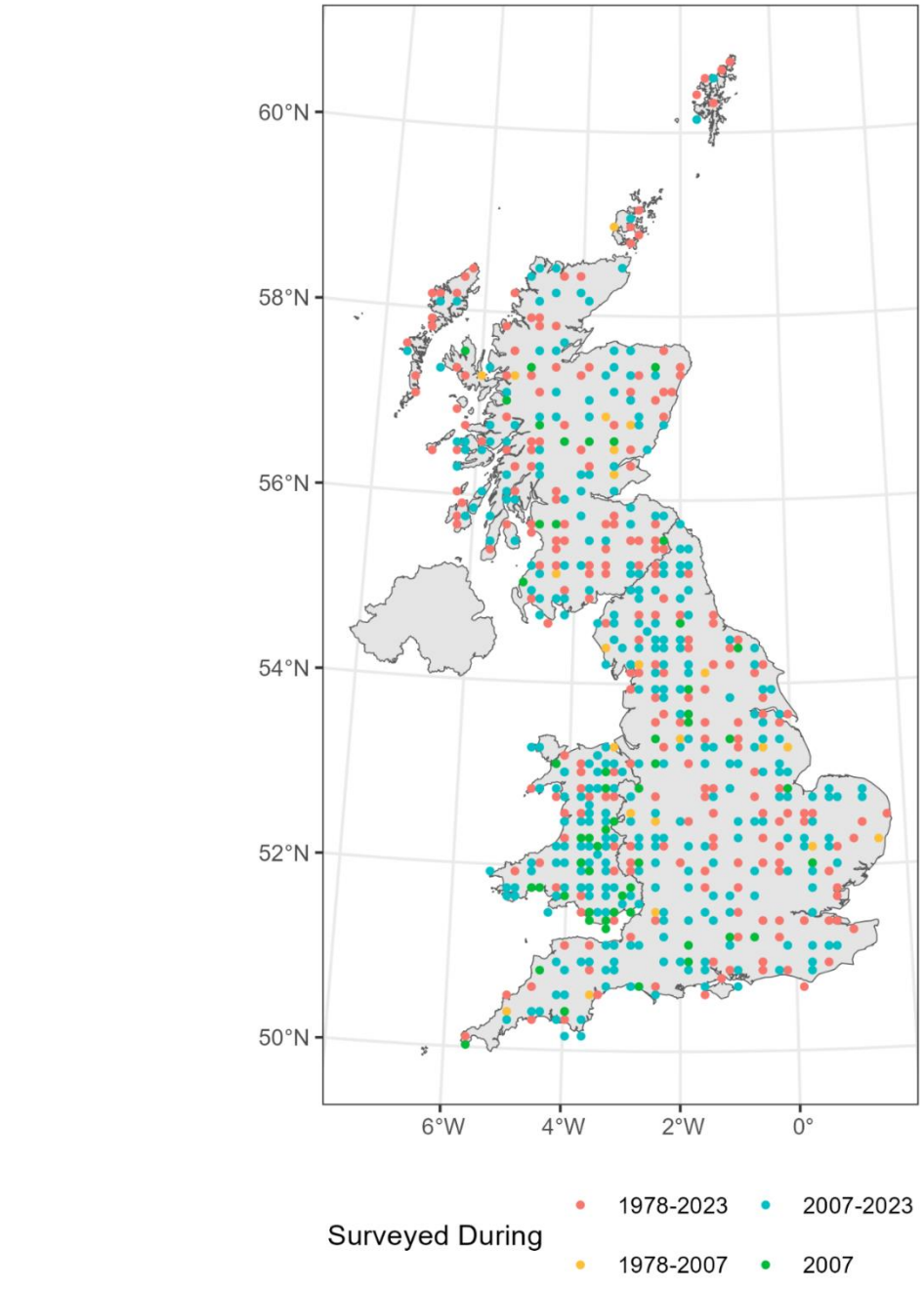


Figure 1 Countryside Survey 1-km square locations (shown at 10-km resolution to preserve the anonymity of sampling locations as per the survey's agreements with landowners), shown for the time period they were active in the survey. The majority of squares introduced in 1978 have been retained within the survey up to 2023. A large number of squares were added in 2007, and a majority of these were also maintained up to 2023.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



1.1 Land class

Bunce (1978) discovered through regional surveys that the analysis of map data could yield strata that might later be utilized to examine a diverse array of ecological characteristics. This approach was broadened to encompass the whole of Great Britain and developed strata grounded in the following information, which includes the fundamental soil-forming factors that can be regarded as relatively stable over decadal time frames: 1) Climate data derived from climatic maps at a scale of 1:1,000,000, representing the spectrum of climatic information accessible for GB; 2) Relief data obtained from the 1:50,000 Ordnance Survey maps, which incorporate features such as altitude and slope; 3) Parent material information regarding the presence of the primary geological series and surface drift categories; 4) Human artefacts data from features available on the 1:50,000 Ordnance Survey maps (Bunce, 1978). Habitats were excluded from the strata due to their variability over time and the fact they are assessed through the survey itself, which would compromise the strata for repeat sampling. Soil types were not included due to the lack of a harmonious classification across all of GB (Barr et al. 1993). Habitats and soil types are instead used as variables in analyses and reporting of the resulting monitoring data.

Over time, the land classes have been improved as computing technology progressed, always taking backwards compatibility of the survey into account. The Land Classes have been stable since the 2007 monitoring cycle (Bunce et al., 2007) when policy needs required land classes be adapted to enable reporting at the level of devolved nations alongside all of GB (Barr & Wood, 2011). This resulted in 45 land classes, which can be mapped easily back to the original 32 land classes (Table B1).

2 Data collection methods and datasets in the database

2.1 Sample collection methods

2.1.1 Plot location and relocation: Within each 1-km square, topsoil samples (0-15 cm) were collected from five plots (subject to permission from landowners) in conjunction with a vegetation survey, that were established on the first visit at randomly dispersed locations within each square. These same plots are then resampled each subsequent monitoring cycle. Plots are located using detailed field sketch maps, photographs, metal plates or posts (from 1990, when soil was not surveyed) and GPS (from 1998 onwards) (Smart et al., 2021). Additional quality assurance is carried out after each field survey to confirm plot relocation by inspecting site photos, field maps and GPS data for consistency between monitoring cycles. If expert judgement suggests a plot has not been accurately relocated in a given monitoring cycle, then any associated data is assigned a new ID to not be considered a repeat of previous sampling. Data from CS2007 showed 85% of plots being relocated across all habitat types (Wood et al., 2018).

2.1.2 Plot design: At each plot and co-located with the soil sampling, a botanical survey is conducted over a 14 m x 14 m square with nested quadrats down to 1 x 1m (Wood et al. 2017). In 1978, soil samples were taken from the topsoil in the side of a soil pit established in the centre of each botanical plot. In each following survey, soil samples were collected from a different corner of the 2 m x 2 m nested botanical survey quadrat (1998: North; 2007: South; 2019-2023: West; Table D1, Figure D.1). As soils are sampled destructively, some noise on resampling is inevitable. This method introduces

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



approximately 2-3 m between successive soil samples, in addition to any noise that is introduced through plot relocation. This protocol was chosen explicitly to minimise the chance that a new sample has been disturbed during a prior monitoring cycle, which was considered a greater priority.

2.1.3 Soil sampling: Sampling procedures have evolved over the CS to improve sample consistency and reliability. In 1978, soil samples of approximately 200g were extracted from topsoil from the side of a larger soil pit, where topsoil was a minimum of 5 cm thick. In 1998 and 2007 a topsoil core (0-15 cm) was taken using a plastic soil core with a bevelled tip (15 long with 5 cm diameter), using a combination of a knife and hammer. In the CS2019-23 cycle, topsoil cores (0-15 cm) were collected using a cylindrical metal soil corer with a cutting shoe at the bottom that is 5 cm in diameter (Robinson et al. 2023). A plastic sleeve is inserted into the corer prior to sample collection to contain the sample and enable easy transfer and archiving. The internal diameter of the plastic core is 5.1 cm, ensuring room for the soil to slide into the core (Figure D.2). This methodology has evolved over the course of the survey to improve sample quality and consistency. Any loose litter is removed prior to sampling, but any fermented or humic layers are retained for sampling. Samples are collected between April and September, to coincide with the vegetation survey.

Across the history of CS, between one and five soil cores have been collected from each plot in close proximity (i.e. 15 cm apart, at the same corner of the vegetation quadrat). The layout of the five samples collected per plot in the 2019-2023 monitoring cycle is shown in Fig. D.1. Routine physico-chemical measures and metrics are collected from a single core where possible, subject to the amount of fine earth within a core. The additional cores then support further analyses as needed and are stored either as air-dried (in plastic bags) or frozen (-20°C) samples (in plastic sleeves from field sampling) in the UKCEH soil bank for wider scientific use in the future. Cores are not bulked to preserve the relationships between co-occurring metrics within each soil core. The use of a single core in analysis does increase susceptibility to short range variation in soil properties on resampling, compared to sampling and bulking multiple cores over a wider area, and thus increases the sample size required in CS to detect a significant effect against background noise.

2.2 Data availability and main soil indicator monitoring data 1978-2023

Data derived from the UKCEH Countryside Survey soils monitoring are regularly published to a data collection on the Environmental Information Data Centre (EIDC) or European Nucleotide Archive (ENA) as appropriate, covering all regularly reported metrics and any additional measures and metrics produced from the UKCEH Soil Bank. The current rolling survey publishes data approximately annually. This data is published alongside co-located data for vegetation and habitat type. Location information is only made available at a 10-km resolution, to protect the anonymity of the sampling sites and prevent knowledge of monitoring locations introducing bias to the management of those sites. Additionally, a soil benchmarking tool is provided through the UKCEH Countryside Survey Soil Health Webtool Soil funDamentals (SOD) (Vigier et al., 2023) and derived maps are available through the UK Soil Observatory (www.ukso.org).

UKCEH maintains an access-controlled database with all 1-km square and plot information data, sample information, soil physio-chemical data, soil fauna data and soil microbiology data from each sampling site in each square surveyed. In

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



addition, data on soil series for the squares visited in 1990 is held, along with basic pedological information collected in 1978. This dataset contains all routine indicators that are now measured and reported on an annual basis (Table 1, Figure 2), along with supporting or less regularly assessed metrics and outputs of bespoke analysis, which are described in subsequent sections. The majority of regularly reported metrics have been measured and reported under a consistent methodology since 1978, but some metrics (e.g. bulk density) are not available for all historic surveys (Table 1).

Table 1 Regularly reported metrics from the UKCEH Countryside Survey for assessment of soil condition and change. Metrics are measured from a single soil core and are currently published on an annual basis under the rolling monitoring program. Metrics calculated for fine earth were calculated after the removal of all stones >2mm.

Column name	Unit	Years available	Description
SQUARE	None	All (1978-2023)	1-km survey square - unique identifier
PLOT	None	All (1978-2023)	Plot number for the soil sampling location (X-Plot)
YEAR	None	All (1978-2023)	Year of survey
PH	None	All (1978-2023)	Soil pH in water measured on field-moist bulk soil (0-15cm) with a ratio of soil to deionised water of 1:2.5 by mass (Avery and Bascomb, 1974). pH is measured on a representative subsample of fresh soil.
LOI	g LOI / 100 g of oven dry fine earth; %	All (1978-2023)	Soil organic matter content of fine earth as measured by loss-on-ignition at 375°C (0-15cm), relative to the mass of dry soil (105°C), (Ball, 1964). Measured 1978-2023. Soil was air dried at room temperature in a forced air flow for a minimum of 14 days, deagglomerated and sieved to 2mm. Samples are loaded into a ThermoGravimetric Analyser. (LECO TGA701) and heated from 25°C to 375°C in two steps. The first step is heating to 105°C and holding for 3 h, the second step heating to 375°C and holding for 15 h. The mass loss between 105°C ($Mass_{105}$) and 375°C ($Mass_{375}$) gives the Soil organic matter content as Loss on-Ignition (LOI) for 2 mm Fine Earth. $$LOI = 100 \times \frac{Mass_{105} - Mass_{375}}{Mass_{105}}$$
C_CONC_LOI	g C / kg of oven dry fine earth	All (1978-2023)	Soil organic carbon concentration of fine earth (0-15cm), estimated from loss on ignition using a corrections factor of 0.55. This correction factor is validated against measurements of total carbon using an elemental analyser for 1998-2023. $$C_CONC_LOI = LOI \times 0.55 \times 10$$
C_STOCK_LOI	t C / ha	2007-2023	Organic carbon density of fine earth (0-15cm). Calculated from

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



			$C_STOCK_LOI = 0.15 \times 10 \times C_CONC_LOI \times BULK_DENSITY$
SOIL_GROUP	None	2007 - 2023	UKCEH-Countryside Survey Carbon groups used in 2007 based on the levels of LOI
BULK_DENSITY	g / cm^3 dry mass of fine earth (g) per unit volume of fresh fine earth (cm^3)	2007 - 2023	Soil bulk density of fine earth (0-15cm). $BULK_DENSITY = \frac{DFE\ (105°C) - stone\ mass}{core\ volume - stone\ volume}$ Where $core\ volume = \pi \times 2.5^2 \times core\ length$ Dry fine earth mass (DFE): After removal of the pH subsample, the remaining sample soil was air dried at room temperature in a forced air flow for 14 days, deagglomerated and sieved to 2mm, prior to heating to 105°C for 3 hours. Stone volume: The volume of stones are derived from the total mass of stones using the density of quartz (2.65 g cm^{-3}). In the measurements of bulk density originally produced for 2007, stone volume was measured through immersion in water. See Appendix 1 for more detail. Dry fine earth mass, stone mass and stone volume are corrected for the removed pH subsample to reflect the mass of the entire core by assuming the same composition of bulk soil in the pH subsample and remaining sample across fine earth, bound and free moisture, and stones.
MOISTURE	g water/g of field moist soil	2007 - 2023	Gravimetric water content of the fine earth fraction per wet weight of soil (0-15cm). Moisture in soil is calculated as the sum of moisture lost during air drying and moisture lost during heating to 105°C for 3hrs (see LOI). $MOISTURE = \frac{FSW + BSW}{DFE + FSW + BSW}$ Where FSW is free soil moisture calculated from the mass of fresh fine earth minus the mass of air dried fine earth soil; BSW is the bound soil moisture calculated from the mass loss between air dried fine earth and moisture lost during heating to 105°C for 3 hrs with a thermogravimetric analyser; and DFE is the mass of dried (105°C for 3 hours) fine earth soil. Dry fine earth mass, stone mass and stone volume are corrected for the removed pH subsample to reflect the mass of the entire core by assuming the same composition of bulk soil in the pH subsample and remaining sample across fine earth, bound and free moisture, and stones.
MOISTURE_DRY	g water/g of oven	2007 - 2023	Gravimetric water content of the fine earth fraction per dry

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



	dry soil		weight of soil (0-15 cm). Moisture in soil is calculated as the sum of moisture lost during air drying and moisture lost during heating to 105°C for 3hrs (see LOI). $$MOISTURE_DRY = \frac{FSW + BSW}{DFE}$$ Where FSW is free soil moisture calculated from the mass of fresh fine earth minus the mass of air dried fine earth soil; BSW is the bound soil moisture calculated from the mass loss between air dried fine earth and moisture lost during heating to 105°C for 3 hrs with a thermogravimetric analyser; and DFE is the mass of dried (105°C for 3 hours) fine earth soil. Dry fine earth mass, stone mass and stone volume are corrected for the removed pH subsample to reflect the mass of the entire core by assuming the same composition of bulk soil in the pH subsample and remaining sample across fine earth, bound and free moisture, and stones.
N_PERCENT	g N / 100 g of oven dry soil; %	1998 - 2023	Total soil nitrogen content of fine earth (0-15 cm) This analysis is carried out on ball milled soil samples. Samples were oven dried at 105°C for 3 h, cooled and sealed prior to weighing. Samples were then analysed using an Elementar Vario-EL elemental analyser (Elementaranalysensysteme GmbH, Hanau, Germany).
N_STOCK	t N / ha	1998 - 2023	Total soil nitrogen content of fine earth (0-15 cm) $$N_STOCK = 0.15 \times 100 \times N_PERCENT \times BULK_DENSITY$$
PO4_OLSEN	mg P / kg of oven dry soil	1998 - 2023	Olsen-phosphorus (plant-available P) of fine earth (0-15 cm); for arable and improved grassland soils only. This analysis is carried out on 2 g of air- dried fine earth soil (<2mm). Extraction uses 40 mL Olsen's reagent (0.5 M NaHCO3 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 analysis was then 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

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



			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.
LC07	None	All (1978-2023)	ITE Land Classification - see Bunce et al. (2007)
LC07_NUM	None	All (1978-2023)	ITE Land Classification number - see Bunce et al. (2007)
COUNTRY	None	All (1978-2023)	GB country (England, Scotland, Wales)
EZ_DESC_07	None	All (1978-2023)	Countryside Survey Environmental Zone description; see: https://catalogue.ceh.ac.uk/documents/0cfd454a-d035-416c-80dc-803c65470ea2

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

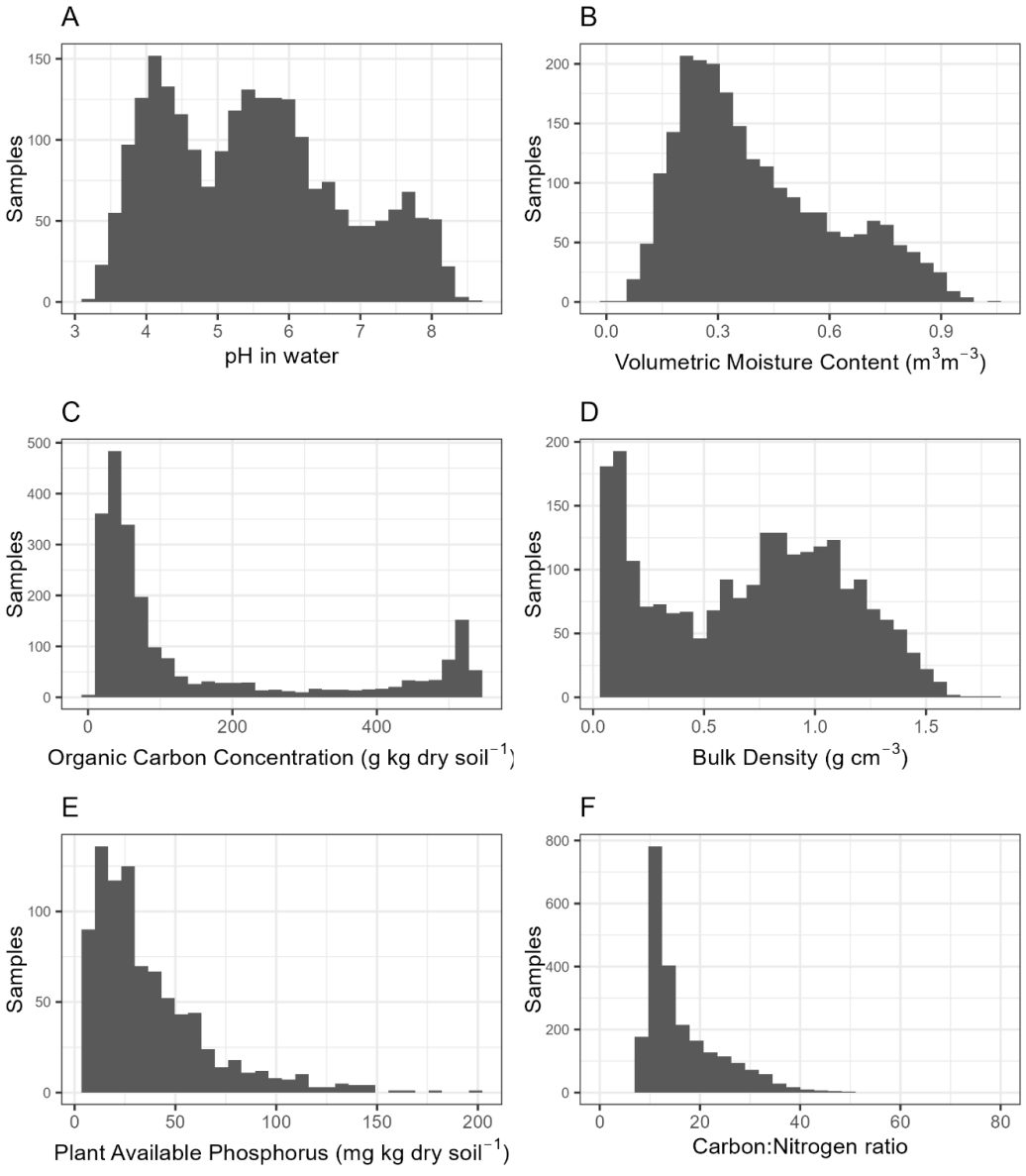


Figure 2 Distribution of values for main soil condition indicators across GB reported by the UKCEH Countryside Survey, as collected in the 2019-2023 monitoring cycle.

2.3 Established national baselines and periodic datasets

A range of soil metrics has been measured on an irregular basis according to need or interest. As a result, the CS holds complete national datasets that are not regularly updated in the current rolling survey but may be repeated in the future. Many of these datasets originated from CS2007 in response to specific policy questions and are not described further below,

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



but are publicly available on the EIDC and ENA. Those metrics included pollutants (heavy metals, Persistent Organic Pollutants), soil fauna (invertebrates, Terminal Restriction Fragment Length Polymorphism and metabarcoding, Figure 7 and appendix E), additional functional metrics and mineralizable nitrogen and carbon, as described in Emmett et al. (2008) and Emmett et al. (2010). Additionally, several metrics have been produced for the 2019-2023 monitoring cycle to aid data interpretation, including particle size distribution, total carbon, calcium carbonate ($CaCO_3$) concentration, aggregate stability, and soil aggregate size distribution. These metrics and others are described in full in Table E1 with references provided in the data availability statement.

2.4 Discrete data sets

A number of discrete datasets have been produced to address a range of scientific enquiries on a subset of the available national samples. These datasets are typically supported through applications to use the CS archived soils at the UKCEH Soil Bank. A brief overview of a selection of these discrete datasets produced to date is given below. For additional metrics, see Table E1.

2.4.1 Functional soil indicators: Simfukwe et al. (2021) analysed 304 samples from CS2007 for additional functional indicators: dissolved organic matter (DOM), soluble nitrogen, reduced nitrogen, microbial biomass, metabolic quotients (the ration of carbon in CO_2 from basal respiration to microbial biomass carbon), microbial quotients (the ratio of microbial biomass carbon to total soil organic carbon), DOM humification and soil respiration. The analysed samples were collected across all major soil and land use types with the CS2007 sample. The dataset is published as supplementary material alongside Simfukwe et al. (2021).

2.4.2 Soil organic matter fractions: A subset of 100 archived samples (2019-2020) were analysed in support of the SOCD project (Reinsch et al. 2024). These 100 samples were selected to capture soils across a range of habitats in GB, which are reported in the associated vegetation data. Data were analysed for soil organic matter fractions (free light fraction, occluded light fraction and the heavy fraction) using density fractionation (Lebron et al. 2025). Sodium polytungstene at 1.8 g cm^{-3} was used based on standard methods (Golchin et al. 2018, Six et al. 1998. Sohi et al. 2001, 2005). Data on soil organic carbon distributed across soil organic matter fractions was correlated with the fraction of carbon in soil organic matter ($r(90) = 0.54$, $p < 0.001$) resulting in a promising indicator of carbon storage in soil organic matter fractions (Reinsch et al. 2025).

2.4.3 Soil Bacteria -16S rRNA:

A comprehensive high-throughput 16S reference database was developed from 1,113 soil samples collected by CS2007. This dataset enables a more detailed understanding of soil bacterial diversity and community structure, as well as their relationships with soil and landscape properties (Jones et al. 2021). Universal Bacteria primers 341f/806r (Takahashi et al., 2014) targeting the V3 and V4 regions of the 16S rRNA gene were used. Sequences were clustered at 97% similarity and singletons were removed, resulting in a total of 39,952 operational taxonomic units (OTUs). This dataset is fully described in Jones et al. (2021), a subset of 13,781 OTUs were relatively prevalent, occurring in at least 30 samples and were therefore of greater value for predictive modelling. This work also produced a public tool (ID-TaxER) in which 16S sequences can be

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



queried against the Countryside survey 16S database to obtain a taxonomic assignment alongside environmentally derived responses (e.g pH or habitat preference) as outlined in Jones et al (2021) (https://connect-apps.ceh.ac.uk/ID-TaxER/) .

2.4.4 Soil spectra (Visible Near-Infrared and Mid-Infrared): A total of 451 soil samples collected during the 2019 survey and 2018 pilot survey were analysed for 1) Visible Near-Infrared spectroscopic analysis, and 2) the ability to predict physico-chemical properties from spectra (Ebuele et al., 2025). Samples were analysed using the ASD AgricSpec spectrometer (350 to 2500 nm at 1 nm resolution), and a subset of 306 samples was also scanned with the FOSS DS2500 spectrometer (400 nm to 2500 nm at 0.5 nm resolution). The dataset also included soil properties used as target variables for prediction, comprising 23 harmonised parameters within the Open Spectra Soil Library (OSSL) prediction engine (Safanelli et al., 2025). These include chemical properties (pH in $CaCl_2$ and H_2O, total carbon, total nitrogen, cation exchange capacity, electrical conductivity, extractable nutrients (Ca, K, Mg, Na, Al, Olsen phosphorus [PO_4]), and soil physical properties (bulk density, particle size fractions, sand, silt, clay, and coarse material). Additional variables are organic matter content, $CaCO_3$, total sulphur, and water retention at WR−15 bar and WR−1/3 bar. For comparative analysis, a subset of 12 measured soil properties from the original survey were selected to compare against spectroscopically derived predictions. Separately, 427 archived soil samples from arable and grassland habitats collected in CS2007 were analysed for mid-infrared spectra (4000-400 wavenumbers per cm) on samples of finely ground soil (Keith et al. 2020).

2.4.5 Winter topsoil physio-chemical properties: An additional field survey was carried out in winter 2021 to visit 146 1-km squares which resulted in the collection of 575 additional soil samples. This field survey was commissioned to increase the data available to facilitate early analysis of soil properties (Bentley et al., 2021). Of those 146 squares, 30 were selected as repeats from the 2021 survey between April and September, sampled across Environmental Zones (Table 1). Priority was given to a subset of habitat types, excluding Broadleaf, Mixed and Yew Woodland, Coniferous Woodland, Bog and Fen, Marsh Swamp, and to 1-km squares with the longest available timeseries and excluding sites where access was refused since 2019. Field practices and data collection followed standard soil collection and processing procedures. Reported soil properties include soil pH, LOI (Lebron et al. 2023), soil carbon concentration, soil carbon stock, bulk density, fine earth volumetric and gravimetric water content when sampled, and total soil nitrogen concentration and stock.

2.5 Archiving: UKCEH Soil Bank

A set of soil samples are archived and kept for future use and analysis. The storage facility at the UKCEH Lancaster site holds air-dried samples (currently over 9000) and frozen samples at -20ºC (currently over 7000). The frozen samples are sent directly from the field and then are frozen whole, since 2007. The samples are linked to the data that is released through the EIDC, with available records going back to 1978. Access to samples is provided through an application process, which can be requested from the soil bank, to ensure that samples are used sparingly and to prioritise additional work that adds value to the public dataset, given the finite nature of the resource.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



3 Co-location with key explanatory variables

Countryside Survey soils data cover a wide range of habitat types and soil types across GB, both of which are key drivers of variation in the soil properties reported by the survey (Figure 3). As such, broad habitat and soil type that has been collected within the survey are frequently used co-variates or reporting categories for CS soils data (Carey et al. 2008; Seaton et al. 2022, Thomas et al. 2020).

3.1 CS Broad Habitat and vegetation data

All soil samples were co-located with an associated vegetation plot. A full census of plant species was recorded in each of these plots. Until 2007, all of these plots were 200 m^2 with a nested in design to facilitate searching the area systematically. The inner most 2 m x 2 m nest is searched first for presence and cover of all species, then additional species are recorded from a further four nests. An overall percentage cover is recorded for all species in the 200 m^2 plot. In 2007, an additional 1 x 1m nest was placed at the centre of the plot with the aim of providing comparative data to other recording schemes underway at the time (in relation to agri-environment schemes) (Wood et al., 2017). From 2019 and beyond, approximately 50% of the plots were limited to 2 m x 2 m due to budgetary constraints. Data from 1978 to 2007 are described in Wood et al (2017) along with links to the published datasets. CS vegetation data for 2019-2023 is available via Smart et al., (2020, 2022, 2024).

In 1978, 1984, 1990, 1998, 2007 and 2019-23 habitat and landscape information was recorded in the 1-km sample squares where the soil sampling sites are located. A full description of this contextual data prior to 2019 can be found in Wood et al (2018). In CS2019-23 habitat mapping was not conducted over the full 1-km square but was recorded following the same protocol for the land containing each soil and vegetation sampling plot and published alongside the vegetation metrics.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

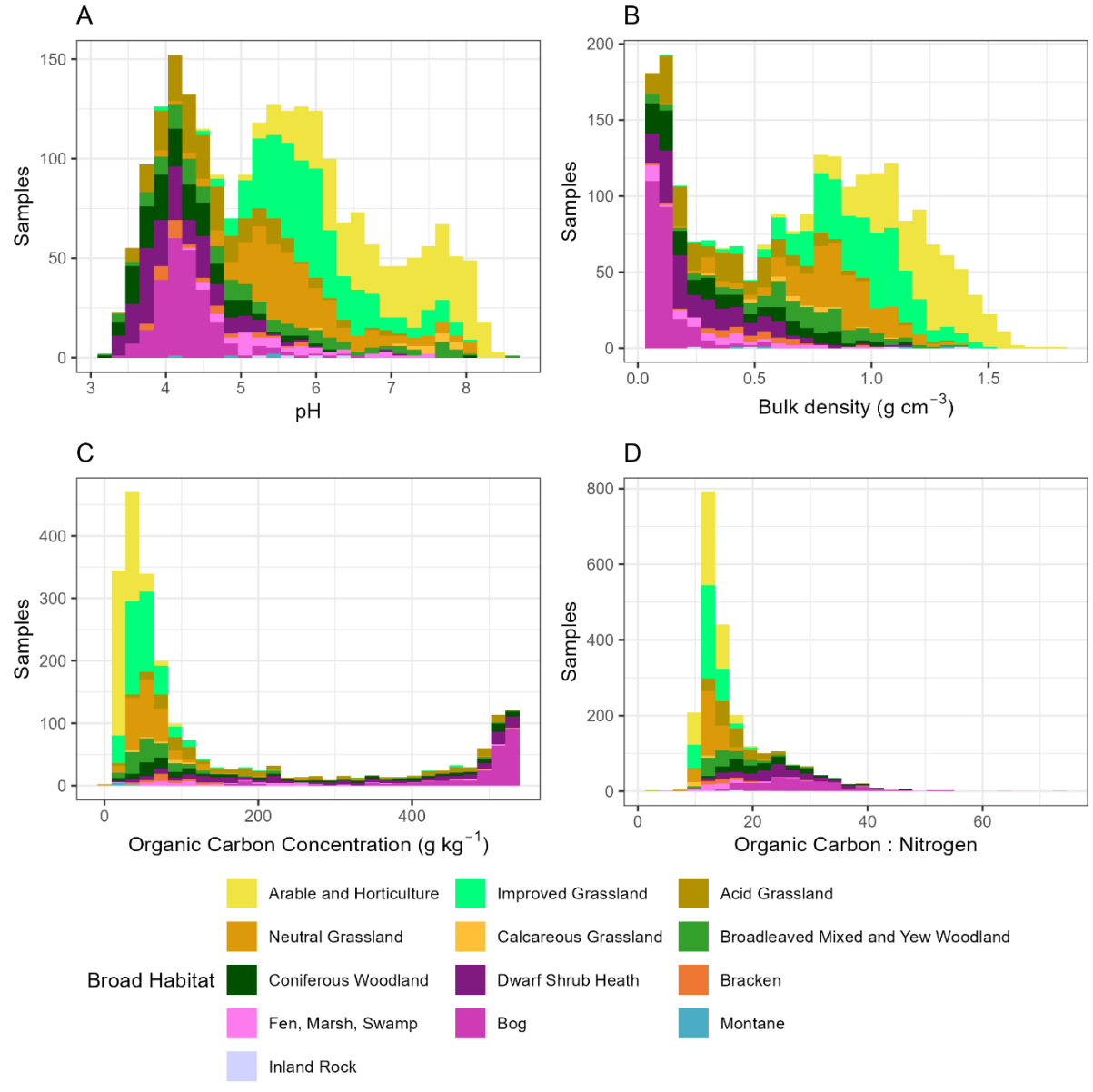


Figure 3 Distribution (number of samples) of values for A) pH (in water); B) Bulk density of fine earth (2 mm sieved); C) Organic carbon concentration, assessed through loss-on-ignition; and D) the ratio of organic carbon concentration to nitrogen concentration, for UK BAP broad habitats in GB, and the contribution of each habitat to the national distribution of indicator values. Data visualised is from the 2019-2023 monitoring cycle of the Countryside Survey. Data for rarer broad habitats within the survey (e.g. supralittoral littoral sediment) have been omitted for visualisation purposes (26 data points).

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

Open Access Earth System Science Data Discussions

3.2 CS soil type recording

Detailed mapping of the 1-km survey squares was undertaken during CS1990 (Barr et al., 1993). The Soil Survey and Land Research Centre (SSLRC) and the Macaulay Land Use Research Institute (MLURI) were commissioned to map 508 of the CS survey squares at 1:10,000 scale resolution and to series level where possible. In this data, soils are classified using a separate taxonomic system in Scotland (Soil Survey of Scotland Staff, 1981, 1984) to the system used for England and Wales (Avery, 1973, 1981). Given that CS is intended to proportionally sample major landscapes at full GB-scale (Figure 4), CS has since adopted a unifying scheme for GB to compare the dominant soils within survey squares (1:10,000 scale) with national-scale maps (1:250,000 scale). This 12-group classification scheme (first presented in Feeney et al., 2023) combines CS soils information on soil texture, organic matter content, depth and GB hydrological context to produce relevant soil types. These 12 groups characterise Soil Natural Capital and associated degradation risks that threaten to compromise ecosystem service delivery (Feeney et al., 2025). Given the sensitive nature of the square locations, this information is not released publicly (Appendix H).

The 12 soil types developed in Feeney et al. (2023) indicate that 1-km squares visited in 1990 were broadly representative of national soil types (Figure 4). Peat and significantly disturbed or excavated soils were over-represented in CS1990 squares by a factor of at least 2 compared to the national maps, with alluvial and coastal soils also more common in square-level maps compared to national maps. For the peat and the alluvial and coastal groups, this may reflect the nature of the ITE land classes used for survey stratification, which captures a mix of mountainous, upland sites where peats are likely to dominate and lowland valleys where the latter soil groups will be common. The CS1990 square population corresponds to the squares sampled in CS1978, but does not include squares introduced following 2007.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

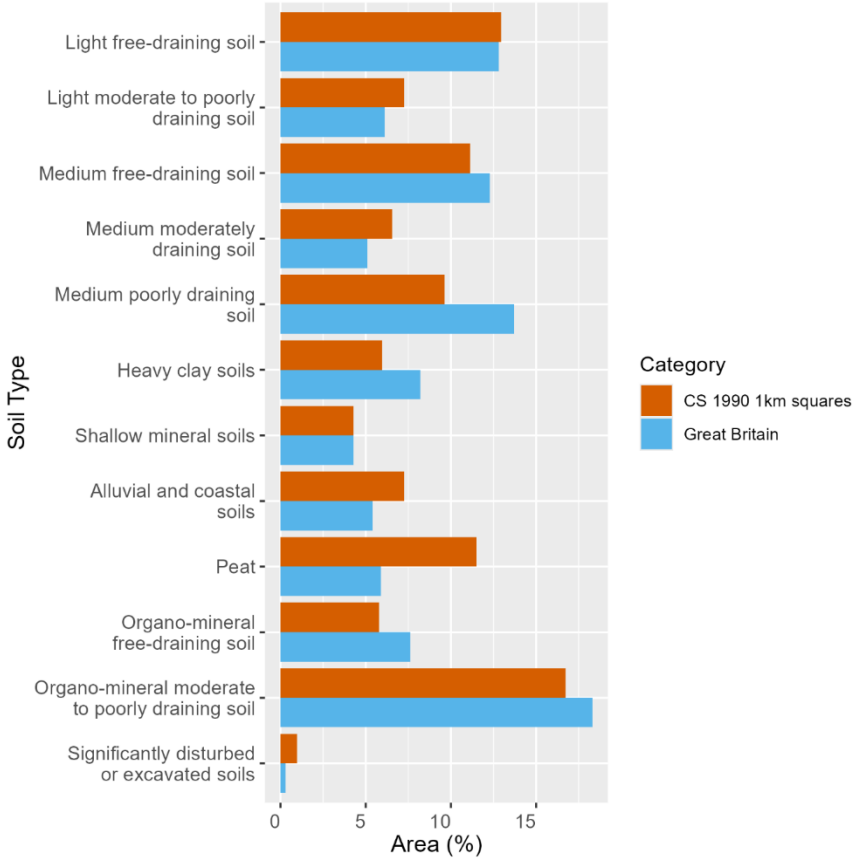


Figure 4 Distribution of area coverage of soil types (as used in Feeney at al. 2023) within Countryside Survey 1-km squares surveyed in 1990 relative to the coverage of those same soil types across Great Britain.

300

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



In addition, soil particle size distributions have been assessed via laser diffraction samples collected in the 2019-2023 monitoring cycle for samples with less than 40% organic matter, enabling the classification of samples by soil texture, described in the supplementary material of Lebron et al. 2025, Appendix F1). The distribution of samples across soil texture groups is shown in Figure 5. As such, the 2019-23 monitoring cycle is compatible with widely used soil texture classifications for analysis and reporting (DEFRA, 2009).

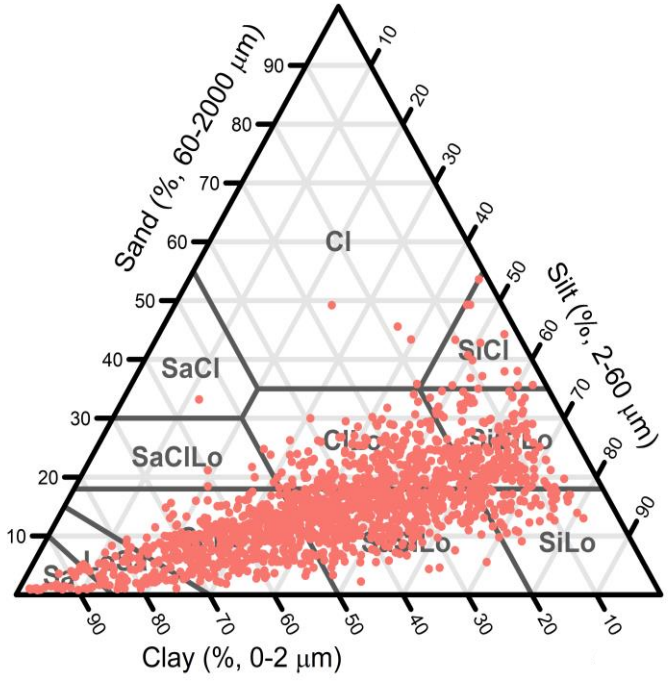


Figure 5 Distribution of mineral and organo-mineral soils samples in the Countryside Survey 2019-23 monitoring cycle, across soil texture classes derived from the relative composition of particle sizes (sand, silt and clay). Data are show for 1603 samples and are not shown for 565 samples with organic matter content over 40%. Figure produced using the Soil Survey of England & Wales classification in the "soiltexture" package by Moeys et al. (2024).

3.3. Recent and future novel additions to the CS soils monitoring

Countryside Survey has continued to evolve in scope in response to policy and science research needs. Within the ongoing 2024-28 monitoring cycle, topsoil sampling has been expanded to include soil sampling in linear feature plots (streamsides, hedgerows and boundary features, Bentley et al., 2025). Hedgerow and streamside plots have been monitored for vegetation in CS since 1978 with boundary plots introduced in 1990, further described in Wood et al. (2017). The linear plot were

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.


established located on their respective feature type as close as possible to the randomly placed vegetation survey plot. In 2024-28, one 0-15 cm soil core is being collected in the centre of one hedgerow, streamside and boundary plot per 1-km square. This is the first national dataset capturing the impact of these linear features on soils and will enable further work on the impact of management of these environmental features on topsoils going forward.

As described in this paper, a growing array of supporting metrics and indicators have been added to public CS datasets over the last five years through collaborations with the wider research community and the use of the UKCEH soil bank. The collection of additional soil cores to support this work was increased in 2019-23 to expand this resource for agile soils reporting for policy and to support wider soils research.

4 Quality Assurance

Quality assurance is carried out through all stages of data collection and processing to ensure data are robust and compatible with historic measurements to enable analysis of change over time (Figure G1). Methods and training materials for CS are reviewed annually. Field data is collected by professional field surveyors who are (re-) trained on an annual basis prior to the survey season, incorporating feedback from the previous years. During the field season, quality assurance visits are carried out by UKCEH field staff during the survey to ensure methods are being followed. Samples are transferred to cooling boxes and fridges as soon as possible, prior to transfer to the laboratories.

With the change from one year of intensive surveying to rolling monitoring cycles, data collection and processing is more continuous and requires a robust system to check and enable quality assurance of data on an annual basis. In CS2019-23, soil samples are tracked using a barcode attached to each soil core, linked to sample specific meta-data. All soil cores are rescanned and photographed on arrival in the laboratory. With respect to the regularly reported metrics, all analytical procedures (pH, loss-on-ignition, nitrogen and Olsen P) are now carried out on two different internal soil standards of known values for each analysed batch (15-25 samples, varying by analysis) of field samples. For loss-on-ignition, a standard sample of pure calcite is also included in each sample batch. Readings for each batch are only accepted where standard values are within ±2 standard deviations of the known mean value. The calibration of the Elementar Vario-EL elemental analyser used for nitrogen concentration is also checked on a working standard (Acetanilide) with a concentration of 10.4% total nitrogen, and the sample data are corrected (factored) against this value. Two Acetanilide standards are analysed at the beginning of every run, with every ten samples and again at the end of the run.

In all monitoring cycles data has been inspected by specialist as part of quality assurance. Since the start of the rolling monitoring program a more structured data processed pipeline has been applied in which all field data, lab metrics, and subsequent derived metrics, are inspected for consistency against field sample records, expected value ranges and distributions and known relationships between metrics to identify outliers, which are then reanalysed. Derived metrics are calculated using a standardised code pipeline and are inspected for outliers, taking into account available meta-data on soil type, land use and historical measurements, with any outliers checked and re-analysed where outliers cannot be explained. All data quality assurance cycles are recorded and version controlled.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



In addition to the procedures described above, soil work carried out in CS is consistent with the Department for Environment Food and Rural Affairs (DEFRA) Joint Codes of Practice (JCoPR) (DEFRA, 2015), which sets out standards for the quality of science and the quality of research processes. The JCoPR provides confidence that processes and procedures used to gather and interpret the results of research are appropriate, rigorous, repeatable and auditable. The laboratories at the UK Centre for Ecology & Hydrology (UKCEH) Lancaster, are UKAS (United Kingdom Accreditation Service; https://www.ukas.com/, last access: 13 April 2026) accredited. UKCEH maintains a quality management system across its four sites which is ISO 9001:2015 certified.

5 Results and uses to date

5.1 Use of the main soil indicators

Soil monitoring by CS has published data from 8,669 0-15 cm soil samples over 45 years, including samples from 2,233 plots and 523 1-km squares in the most recent monitoring cycle (2019-2023). Additionally, over 16,000 CS soil cores are stored in the UKCEH soil bank for future use. The UK has a long history of soil condition monitoring at scale (see section 6.2), however CS is unique in its cross-GB coverage and duration. With the introduction of a soil survey to the 4th UK nation, CS Northern Ireland (DAERA, 2026; not otherwise described here), this extent is expanded to the whole of the UK. As such, CS is the longest running, nationally representative soil monitoring program for GB, with 20 soils datasets published to the EIDC.

A large number of books and reports have been published following from historic CS monitoring from 1978-2007 (e.g. Black & Kennedy, 1999; Black et al. 1998; Black et al. 1999a; Black et al. 1999b; Black et al., 2008; Emmett et al. 2010; Reynolds et al. 2013) detailing key findings in soil condition and change. Across these reports, the regularly reported soil indicators give an overview of soil condition. The data capture variability across habitats and soil types and responses to an array of threats and pressures. Soils in GB show substantial variation, with pH varying from 3.2 – 8.6 and organic matter content varying from 1-100%. Nonetheless, prevailing relationships are clearly present, both within and between metrics across habitats (Figure 6, Figure 7, Figure 8), associated with dominant vegetation type and management. The most recent CS national soils report (Emmett et al, 2010) found that the mean pH of soils (0-15 cm) significantly increased in less acidic soils across GB between 1998 and 2007, continuing a trend observed between 1978 and 1998 that is consistent with the expected outcome of reduced sulphur emissions and acid rain. However, more recent work published by Seaton et al. (2022) shows that this trend has now reversed, with significant decreases in soil pH between 2007 and 2019, potentially associated with reduced rainfall relative to 2007. This agrees with national trends for Wales which reported a similar recent decrease in soil pH (Emmett et al. 2025). Emmett et al. (2010) also reported that there was no change in carbon concentration in the soil (0-15 cm) in GB as a whole between 1978 and 2007. This GB trend contrasts the losses reported by the National Soil Inventory (Bellamy et al. 2005) that long-term losses in soil carbon had occurred in cropland from 1978-2007. Bentley et al. (2025) has extended the analysis in Emmett et al. (2010) to the most recent CS monitoring cycle for arable and horticultural soils, reporting a statistically significant increase in soil carbon concentration and stocks since 2007 for GB. Additionally,

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Emmett et al (2010) reports that despite reported declines in atmospheric deposition, only relatively small changes in soil trace metal concentrations occurred in soils between 1998 and 2007, due to the long residence time of metals in soils.

Beyond these reports, CS has provided data and national statistics on soil condition to the Office of National statistics (e.g. ONS, 2024), and the Welsh Government's State of Natural Resources Reports (NRW, 2025; Emmett et al., 2025). CS soils data has also been used in over 200 publications since the 1990s for a variety of research purposes, including reporting on national soil condition (Bentley et al. 2025; Reynolds et al, 2013; Keith et al., 2015; Norton et al., 2012), identifying drivers of change in the condition of the wider countryside (e.g. Seaton et al. 2022), acting as benchmarks for soil condition under restoration or land use change (Carvalho et al. 2025; Feeney et al. 2023); developing and testing new indicators of soil health, including in collaboration with the EU (Reinsch et al., 2025, Jones et al. 2021) and underpinning research into threats and pressures and fundamental processes in soil systems in GB (Robinson et al. 2022, Thomas et al.2023, Lebron et al. 2025).

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

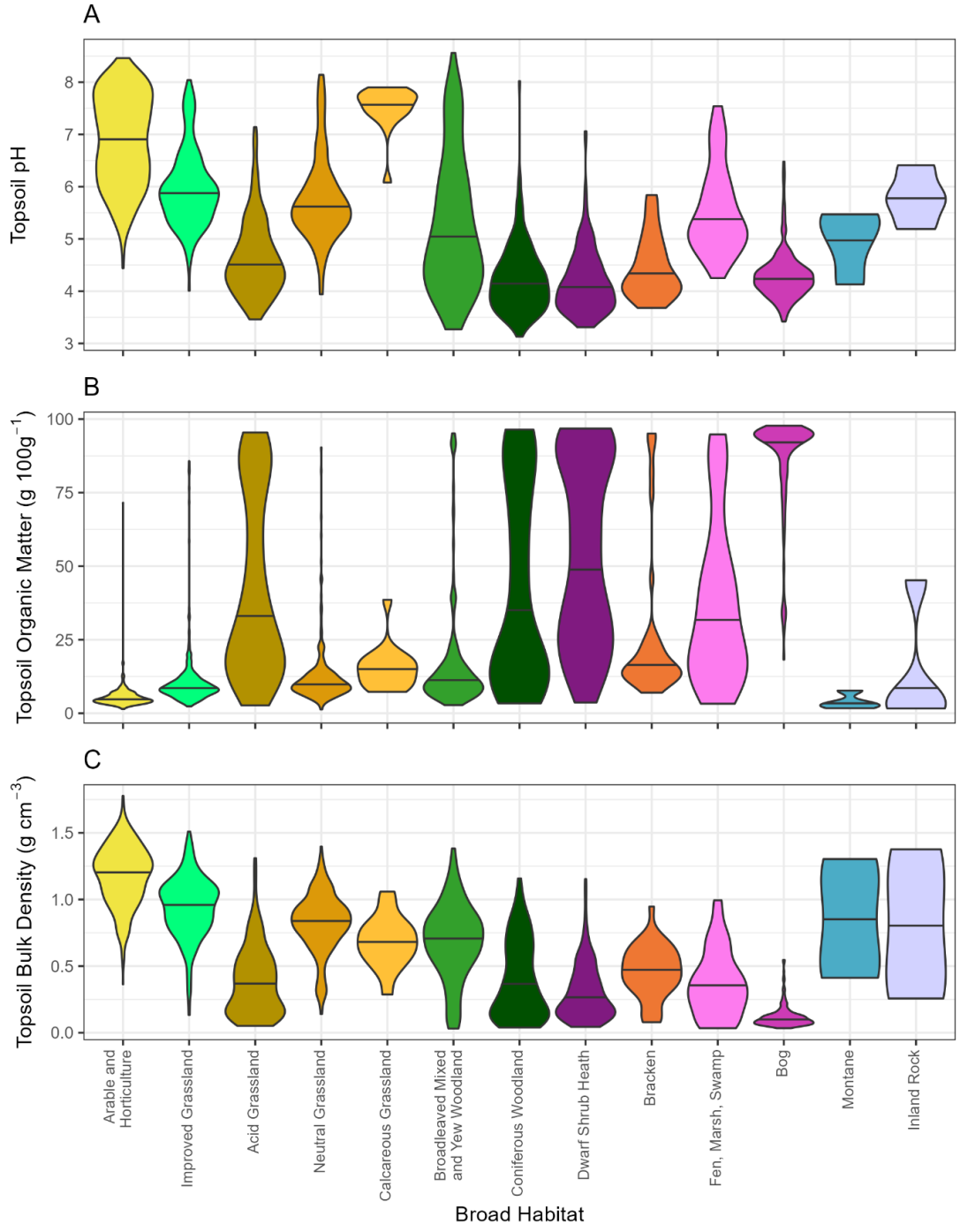


Figure 6 Distribution of values for A) pH in water, B) organic matter concentration, and C) bulk density of fine earth (2 mm) across GB topsoil, using data from the Countryside Survey 2019-2023 monitoring cycle, demonstrating the trends in mean and distribution across improved and semi-natural systems. Data production described in Appendix E.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

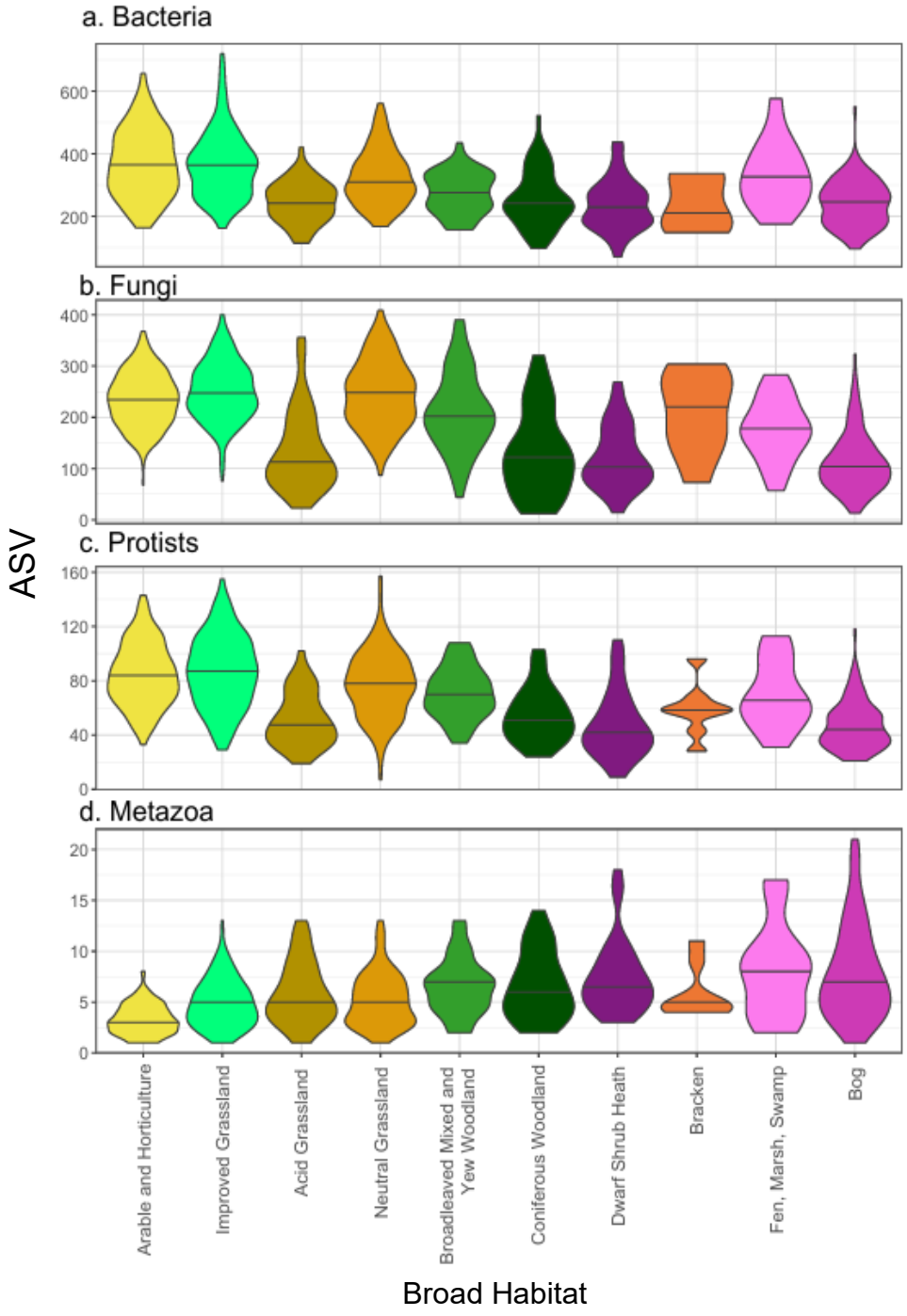
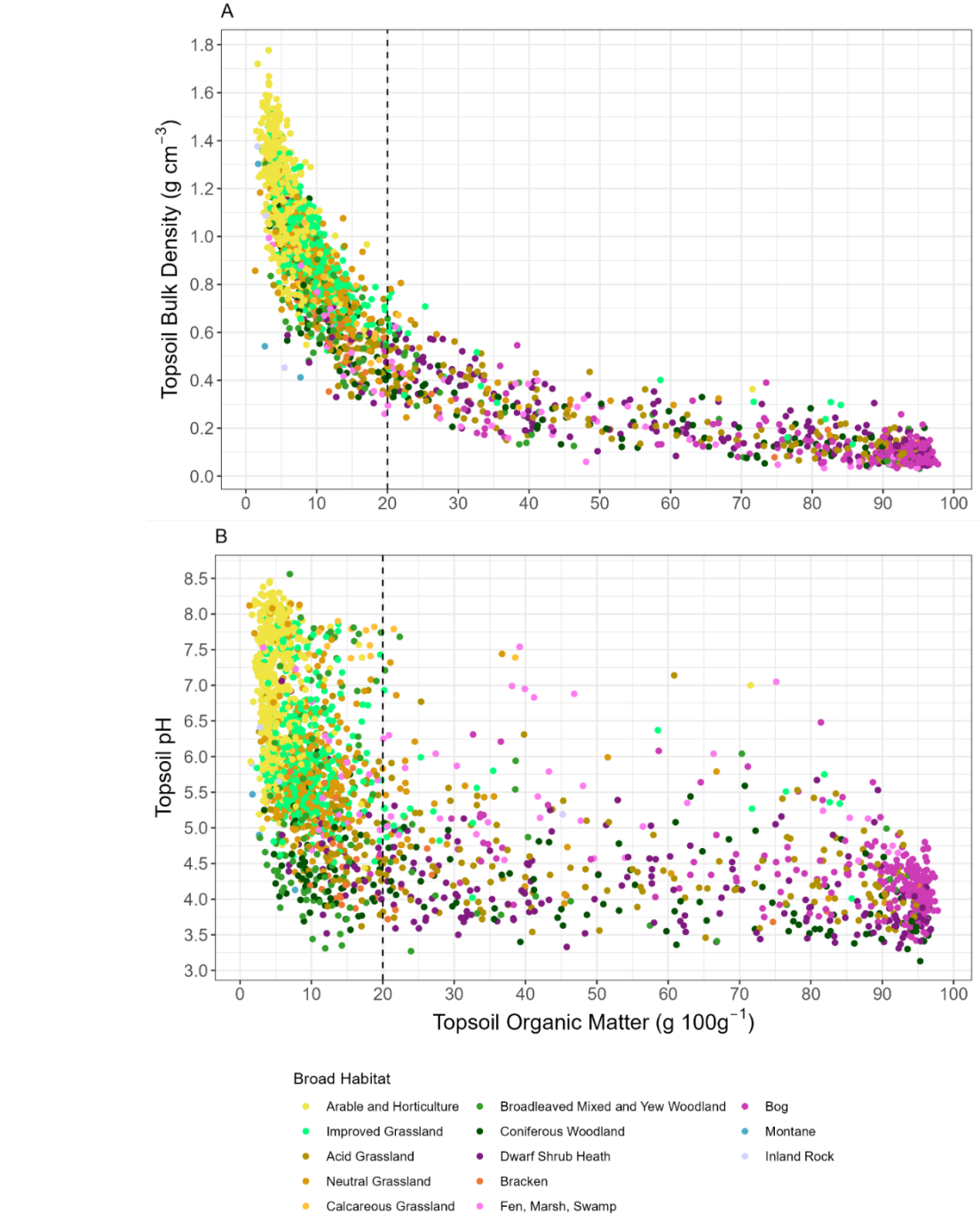


Figure 7 Distribution of values of amplicon sequence variant (ASV) richness for A) Bacteria, B) Fungi, C) Protists, and D) Metazoa across GB topsoil, using data from the Countryside Survey 2007 monitoring cycle, demonstrating the trends in mean and distribution across improved and semi-natural systems. Data production described in Appendix E.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



405

Figure 8 Relationships between A) bulk density of fine earth (2 mm) and organic matter content, and B) pH in water and organic matter content, in topsoil (0-15 cm) across Great Britain, collected in the Countryside Survey 2019-23 monitoring

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



cycle, shown by broad habitat. The dashed line indicates 20% organic matter content, which is a widely used threshold for distinguishing mineral from organic matter rich soils.

5.2 How the data should and shouldn't be used

Countryside Survey topsoil data has a wide number of potential applications, as described in Section 5. The main strengths of this long-term data set are: 1) it's nationally representative composition, which means it is able to capture much of the full range of environmental variation present within GB required for model training and validation, the ground truthing of remote sensing data and enables the data to act as a national benchmark for soil properties under different land uses, soil types and climate zones; 2) the co-located survey design and the use of a single soil core to underpin the majority of analysis and lack of sample bulking, which mean that metrics reported by the countryside survey are closely linked in time and space, to support integrated analysis across metrics. This supports understanding of soil function and enables driver analysis; 3) the use of a consistent methodology over five decades, which allows for the assessment of changing soil properties through time; and 4) the implementation of a consistent methodology across England, Scotland and Wales and now separately, Northern Ireland, allowing consistent reporting across GB and now the four nations of the UK.

The design of CS also results in a dataset that requires careful use, when seeking to understand national soil condition and change. The hierarchical sampling design (multiple soil samples within each 1-km square) should be taken into account in analysis, for example through the use of survey square as a random effect (Scott et al. 2008). Additionally, data users should consider the role of temporal autocorrelation on analysis outcomes when using more than two monitoring cycles of survey data. The dataset as a whole is designed to be nationally representative, and as a result analyses at national scale may not require direct controlling for ITE land class in the analysis (Scott et al. 2008; Bentley et al. 2025). Users should also be aware that no repeat samples occur within a monitoring cycle, only between monitoring cycles, and therefore data from a single rolling monitoring cycle (e.g. 2019-23) should not be used in isolation to understand change over time. Simultaneously, each monitoring cycle will contain data gaps, due to changes to the population of 1-km squares over time caused by incomplete land access permissions, or other causes of missing data. This can be accounted for through widely available statistical methods to mean estimates for a consistent sample over time, as described in Scott et al. (2008) and elsewhere (Cnaan et al, 1997; Bell et al. 2015; Heikkinen et al. 2013; Bentley et al., 2025).

The soil sampling methodology used in CS also warrants specific consideration when using the dataset. When using a subsample of the dataset, data users should take care to not assume that individual data points are representative of the broad habitat, soil type, field or land parcel they were collected in, or that repeat samplings at individual points are representative of site level change. Some soil metrics can show a large amount of heterogeneity over small spatial scales, and values of individual points, or change over time in an individual point, can be misleading (Lark et al., 2012). This short-range variation in soil properties adds noise to analysis that can be compensated for through the use of a larger sample size. Short-range variation poses a particular challenge in organo-mineral soils, where the variation in the thickness of the organic layer over a short distance can be large, and users should be aware of this when assessing change between surveys. In addition, CS soil cores are fixed depth samples (0-15 cm). The potential for this to result in misleading changes in indicator values, where

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



changes in bulk density have also occurred, has been widely discussed (Rovira et al., 2022; Raffeld et al. 2024) and users of the data should take care to take this possibility into account in their interpretation of the data.

CS soil sampling locations are publicly disclosed at a 10 km resolution only, in order to 1) preserve the anonymity of the sampling sites and 2) prevent local shifts in management in response to survey results, making future surveys less nationally representative. For many applications of the data, the co-located site data from within the survey and 10 km resolution locations will be sufficient. Under rare and specific circumstances, it is possible for sampling locations to be shared at a higher resolution, requiring a separate data sharing licence issued by the UK Centre for Ecology & Hydrology (Appendix H). Finally, when seeking to combine CS soils data with data from other soil surveys or data, consideration should be given to 1) similarity of field methodologies, 2) time of year of soil collection 3) soil sampling depth and 4) similarity of lab methodologies. Each of these differences can impact the comparability and compatibility of data sources.

5.3 Comparison to similar existing datasets

The UK has a long history of soils monitoring at scale through multiple programs including: the National Soil Inventory across England and Wales from 1980-2003 partial resurveys (NSI, Bellamy et al, 2005; Lark et al., 2006), the National Soil Inventory of Scotland from (NSIS; 1978-88 & 2007-2009, Lilly et al. 2010; Farmer et al. 2016), ERAMMP (2021-2025, Emmett et al., 2025; Bentley et al., 2025) and its predecessor the Glastir Monitoring Environmental Programme (GMEP, 2012-2026, Emmett et al. 2017) in Wales; the Northern Ireland Countryside Survey (DAERA, 2026) in Northern Ireland, the Natural Capital Ecosystem Assessment and England Ecosystem Survey (EES) in England and LUCAS across the EU and UK (Orgiazzi et al. 2018). This list does not include the many high quality local, or habitat specific soil monitoring datasets collected in the UK (e.g. National Forest Inventory Plus, NFI+, Forest Research, 2025; the Soil Nutrient Health Scheme in Northern Ireland; long-term single site monitoring such as described in Poulton et al. 2024). Some of these programs (ERAMMP, GMEP, CSNI) publish soils data that is directly comparable with CS data, whilst others have varying degrees of difference relative to CS, although a full comparison across all programs is beyond the scope of this paper. Typically, these differences stem from the surveys having diverse aims and reporting priorities for the resulting data. Sampling design, soil sampling depth interval, field methods and laboratory protocols can also vary between these UK surveys, making direct data integration challenging, across the original datasets and products derived from the different sources (Feeney et al., 2022).

Across the UK's national soil datasets, CS is unique in its spatial extent (GB), duration (1978-present) and number of monitoring cycles for soils (four complete with a fifth in progress). At the same time, CS is limited to topsoil (0-15 cm), whereas several other historic monitoring programs have reported to greater depths (up to 1 m in NSIS; 45 cm in EES). Changes in topsoil are dominated by the impact of land management on soils (Schneider et al., 2021; Thomas et al. 2020) but are an incomplete representation of soil carbon stocks. CS has a lower sampling intensity per ITE land class than other programs with a similar sampling design that are designed to cover a smaller spatial extent (ERAMMP; GMEP; EES), but samples GB at a higher intensity than LUCAS. Whilst some national soil surveys (CS, ERAMMP, GMEP, CSNI, EES) use a stratified random sampling approach by ITE land class, LUCAS implements a stratified random sample by broad habitat,

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



and NSI and NSIS implement a gridded sampling approach on 5 km and 10 km grids, respectively. This influences the spatial data coverage of these different datasets and the degree to which they are likely to capture environmental variation across the respective nations, with impacts likely varying by use case. Finally, the approach to soil sampling in the field also varies across programs. Whilst CS uses a single soil core for analyses, due to the emphasis on national scale analysis, LUCAS, NSI and EES use bulked soil samples across multiple cores per plot.

Data Availability

The datasets containing the regularly reported metrics and complete national topsoil baselines from CS over the last 50 years can be found at the references listed in Table 2. Additional related datasets that may be of interest as described in Section 3 are further described in Appendix E. All data is available under the terms of the UK Open Government Licence. To enquire about accessing material in the UKCEH soil bank, the soil bank can be contacted directly (uksoilbank@ceh.ac.uk). Supplementary information provided with these datasets provides guidance on the use of the data and references to field handbooks, describing all field methods used in the survey in detail.

Table 2 References and DOIs for regularly reported metrics in the UKCEH Countryside Survey and complete national baselines

Title	DOI	Reference
Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2023	https://doi.org/10.5285/fe58d52e-f00c-4895-a35e-26b7353cc275	Bentley et al. (2024)
Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2022.	https://doi.org/10.5285/d53fdf1d-767a-4046-821a-ea645001ddd3	Reinsch et al. (2023)
Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2021.	https://doi.org/10.5285/af6c4679-99aa-4352-9f63-af3bd7bc87a4	Bentley et al (2023a)
Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2020, v2.	https://doi.org/10.5285/6a3382cc-f5f4-4d68-9517-c62fadd8af4f	Bentley et al. (2023b)
Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2018-2019.	https://doi.org/10.5285/821325f3-b353-4a51-8db2-6b2200d82aca	Bentley et al. (2023c)
Soil physico-chemical properties 2007 [Countryside Survey]	https://doi.org/10.5285/79669141-cde5-49f0-b24d-f3c6a1a52db8	Emmett et al. (2016a)

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Soil physico-chemical properties 1998 [Countryside Survey].	https://doi.org/10.5285/9d1eada2-3f8b-4a7b-a9b0-a7a04d05ff72	Black et al. (2016a)
Soil physico-chemical properties 1978 [Countryside Survey].	https://doi.org/10.5285/85c71959-0f7c-4f04-b3a7-152673107a85	Bunce et al. (2016)
Topsoil particle size distribution, electrical conductivity, calcite and total carbon from the Countryside Survey of Great Britain for 2018-2023, and aggregate information for 2019.	https://doi.org/10.5285/6893097f-f504-4b77-96c8-8daa5da6a09d	Lebron et al. (2025)
Topsoil mineralisable nitrogen (mineral-N) data 2007 [Countryside Survey].	https://doi.org/10.5285/3bafb72b-9f2a-4cbc-a7b8-46e3731c6759	Emmett et al. (2016b)
Soil metals data 2007 [Countryside Survey].	https://doi.org/10.5285/826b0829-7ab5-4e22-822f-ee3a137896a9	Emmett et al. (2016c)
Soil invertebrate data 2007 [Countryside Survey].	https://doi.org/10.5285/fccd86b0-f5b6-4716-b4f7-f43ad82daeee	Emmett et al. (2016d)
Soil metals data 1998 [Countryside Survey].	https://doi.org/10.5285/def15f47-6aba-43db-a833-5844628a658b	Black et al. (2016b)
Soil invertebrate data 1998 [Countryside Survey].	https://doi.org/10.5285/f3e71ba6-bfd7-4841-9ce4-fd1f0d590d2d	Black et al. (2016c)

Project URLs:

https://www.ceh.ac.uk/our-science/projects/countryside-survey

Conclusions

The soils data provided through the UKCEH Countryside Survey are an invaluable asset for supporting an understanding of the properties and processes impacting GB soils over policy relevant timescales. The data are designed to capture a national representative sample of the countryside in GB along with the full spectrum of environmental variation present within, and provide standardised, quality-controlled metrics over long timescales. The integrated monitoring design and co-location with vegetation and habitat metrics in both time and space offers a unique potential for integrated analysis of both, environmental drivers of change, and cascades of responses to novel environmental pressures such as climate change or shifting land management practices. Regularly reported metrics for each monitoring cycle provide a robust framework for assessing national topsoil status and change, with data collection actively ongoing in the next monitoring cycle (2024-28). In addition, the UKCEH soil bank provides a window into the history of our soils at national scales.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Appendices

Appendix A - The Countryside Survey Design and History

We have aggregated key information and reference from across the history of the Countryside Survey (CS) to answer the key questions frequently asked about the CS soils monitoring data (Table A1). These topics are covered in brief in the main text, but these resources (answers a-l and further referenced in TableA1) provide additional detail that may be useful to some users.

a) What are the design principles behind the Countryside Survey?

The UKCEH CS is an audit of environmental condition at national scales. The core objectives of CS are to report on the condition of the national environment and how that condition has changed over time. Additional objectives include understanding the drivers of those changes and what the wider implications of those changes might be. In the past, the CS has also been required to address specific policy-relevant questions about the condition of the environment for Great Britain and the devolved nations. This has a number of consequences for the design principles behind the Countryside Survey which are discussed at length in Robinson et al. (2024). Components of the statistical design are expanded upon in Kirk et al. (2011) and Scott et al (2008).

In brief, some of key considerations are (see Robinson et al., 2024 Table 2 for a full list):

1. A lack of bias. Design based sampling and model-based statistics are used to give unbiased estimates of national means and variance. This is done using a stratified random sample of Great Britain as described below and in the main text.

2. Repeatability and reliability. Methods and procedures must be compatible with those that were possible to implement when the monitoring began in 1978 to ensure change is not being driven by changes in methodology. In addition, methods must be feasible to implement at scale to provide a suitable sample size.

3. Co-location of indicators. The co-location of soil and vegetation monitoring in space allows integrated analysis across the indicators measured in the survey and a greater ability to understand the relationships between them and possible drivers.

4. Flexibility. Build flexibility into the monitoring system design to accommodate changing circumstances, evolving priorities and new information.

5. Timeliness and measurability. The monitoring must capture the essential time scales of the processes concerned and be able to support timescales for decision making and intervention. In addition, the indicators measured must be sensitive to change and specific enough to support understanding and address a variety of questions.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



6. Ethical considerations. The monitoring must be in line with ethical principles related to privacy, confidentiality and informed consent when collecting and using monitoring data. This is of particular relevance when collecting data from private land.

b) Why use a stratified random sampling design?

The stratified random sampling design in CS achieves several underpinning objectives of the monitoring program highlighted above:

1. It enables us to ensure we capture the full range of environmental variation present in Britain, captured through the strata used, whilst collecting a sample that is nationally representative as a whole due to relative sampling effort and statistics used. Whilst capturing equivalent environmental variation would be possible with a purely random sampling, using a stratified approach allows us to reliably capture this variation with fewer total samples and greater cost-effectiveness.

2. The design is flexible, allowing us to increase or decrease overall sampling intensity without biasing the sample.

3. It is compatible with a variety of analytical approaches, but at its core the design-based statistics for stratified random sampling are straight-forward to compute.

c) What are the ITE land classes?

The Institute of Terrestrial Ecology (ITE) land classes were developed by Bunce and Shaw in the early 1970s from the multivariate analysis of 75 environmental variables, including climatic data, topographic data, human geographical features and geology data. The land classes were composed to provide the environmental strata for national ecological survey. A detailed description of the development and refinement of the ITE land classification is given in Barr & Wood (2011). The ITE data layers for 2007 is available on the Environmental Information Data Centre with the references below:

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. https://doi.org/10.5285/5f0605e4-aa2a-48ab-b47c-bf5510823e8f

d) How is the sampling frequency per land class decided?

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



In CS 1978 and CS 1998 the number of 1km squares surveyed for soils monitoring per land class was eight, due to resource limitations at the time. Squares were sampled randomly within each land class. Analyses at the time were designed to take the identity of land class into account and provide unbiased national estimates.

In CS 2007, the ITE land classes were refined to allow reporting for each of the devolved nations of Great Britain and increase the number of land classes from 32 to 45. The process involved in this is described in Wood et al. 2011. The total number of 1km squares was also increased. All original squares were preserved, with new squares added such that the final number in each land class was proportional to the area of each land class and a minimum number of 6 squares per land class was achieved. As such, the overall sample from 2007 onwards is assumed to be representative of national variation.

The number of squares in each land class used in the history of the Countryside Survey is given in Barr & Wood (2011). The implications of this change for analysis are discussed below and addressed in Scott et al. (2008) and Kirk et al. (2011). There will always be differences between a desk-based design and a practical realisation of such a large-scale survey where issues such as site rejection can cause challenges. Despite practical challenges, the observed number of sampled squares is proportional to the number of 1km squares within the land class and any discrepancies resulting from these challenges was determined to be inconsequential.

e) How has sampling effort in the Countryside Survey changed over time?

There are two key sources of variation in the sampling effort of the CS over the multiple monitoring campaigns. In this case, we are only discussion sources of variation that impact the soils monitoring in the CS.

1. The number of 1km squares used for soil sampling increased from 256 in 1978 and 1998 to 591 in 2007, and the decreased to 500 in CS2020 with the adoption of a rolling survey, where 100 squares would be surveyed per year and a complete monitoring cycle carried out over 5 years.

2. Within squares, five plots are used for soil sampling to provide replication as described in the main text. However, the ability of the CS to sample each plot is dependent on landowner permissions to access the land. This means the number of plots surveyed in a square can change over time, although rates of landowner approval are typically high (>90%).

The analysis of CS data has been designed to be robust to specific plots or squares being absent in some years, as discussed below.

f) How does the design of the survey account for changing research questions that might be asked of it whilst retaining the integrity of long-term monitoring and analysis?

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



This can largely be accounted for by the central design principles of the survey, as discussed in Robinson et al. (2024). The core value of the survey comes from its long-term integrity and therefore any changes that would fundamentally compromise that, cannot be made. Where changes in technology or methods are necessitated, efforts must be made to ensure that any new data is backwards compatible and the impacts of any change in methodology are well known. However, where new questions arise that require an increase in sampling intensity or the introduction of a new indicator, that change can be made as long as it does not compromise the existing monitoring.

The stratified random sampling design allows for the monitoring program to expand or contract whist maintaining the core structure and the modelling approach used to analyse long-term trends is robust to changing sample sizes over time, or incomplete resurveys in a specific timepoint, as elaborated on below.

Additionally, the presence of the UKCEH soil bank, where all soil cores collected in the monitoring program are archived, allows the possibility of revisiting historic samples to measure new indicators and address new questions.

g) How are plots relocated and how accurate is plot relocation?

The process of plot relocation is described in Wood et al. (2018) and is described in Countryside Survey field handbook (Smart et al. 2021).

Plot relocation uses a combination of methods to increase reliability. These are:

- Re-training field surveyors in plot relocation methods each year prior to the field season and conducting field quality control visits to ensure procedures are followed.
- Recording plot GPS coordinates and relocating these. This was introduced in 1998. However, GPS accuracy varies across the square and plot locations and user errors occasionally occur, therefore this is not the only method we use to confirm plot relocation.
- Plot photographs – plots are photographed from multiple angles to capture key features of the landscape to aid in future relocation. Photos from previous visits are provided to surveyors to aid relocation and updated each visit.
- Field maps – The location of each plot is recorded in a surveyor-drawn sketch map that includes distances to key features to triangulate the plot location. This is also updated each visit as needed. An example of this is given in Wood et al. (2017).
- Metallic plates – Each plot contains a metal plate in the south corner which is relocated with a metal detector. Surveyors record specifically whether a plate has been relocated to support subsequent quality control. Finding a metal plate is a reliable sign of plot relocation. However, metal plates can sink over time, therefore the lack of a metal plate is not a definitive sign that plot relocation has failed, if accompanied by an accurate GPS agreement and consistent photographs.
- Plots are orientated along cardinal axes to facilitate accurate relocation of the entire plot from specific points.

All plot relocation data and supporting information is reviewed post-data collection as part of the quality control process. Considering all of the above, if plots were not relocated in the field or expert judgement during quality control determines that a plot may not have been relocated, those plots are assigned a new ID for the purposed of analysis.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



In the 2007 Quality Assurance exercise for plot relocation it was found that 86% of plots had been accurately relocated across all surveyed habitat types (Prosser and Wallace, 2008). Surveyors also report that plot relocation in unenclosed habitats can be more challenging to confirm due to a lower abundance of distinguishing features.

h) How does variable access to plots in the field impact analyses of national trends?

Variable access to plots creates a challenge for consistent reporting where estimates of stock and change are not derived from consistent populations. All plots present in a specific cycle would contribute to that mean, but only those visited in multiple cycles could contribute to change. Therefore, we have implemented a modelling approach to estimating stock and change that allows us to make the best use of the data a statistical power available to us whilst providing consistent estimates of stock and change, that are not impacted by intermittently missing data points. This approach is discussed in depth for soil analyses in Annex F of Emmett et al. (2008). These models use a mixed effects and repeat measures statistical model, applied to data from all monitoring cycles. By incorporating a temporal autocorrelation structure by square and plot ID the model effectively corrects for missing datapoints in a given modelling cycle when estimating overall mean and change. As such, intermittently missing plots will not bias the overall estimate for that time window. However, analytical power to detect change remains limited by the sample size, and thus the power to detect change from 1978 to 1998 is lower than from 2007 to 2020 for example.

The process of constructing this analytical approach is described in Annex F of Emmett et al. (2008).

i) How does the change in ITE land class system and sampling effort in 2007 impact national trend analyses?

The change in the ITE land classes used throughout the history of CS does not impact estimates of stock and change national estimates in any significant way. This is because the new land classification maps entirely to the original 32 class system. The new classification was created by subdividing some of the 32 classes to enable country level reporting and to refine the granularity of analyses that are possible. The 2007 ITE classification makes possible reporting at GB level and for individual nations and is the preferred reporting system going forward. This means current estimates cannot be directly compared to those published before the adoption of the new system.

The key change is not in the stratification itself but in the overall sample size and how it is allocated across the strata. A fundamental constant across all surveys is that each strata has a minimum of 6 sampling units (1km squares). This ensures sufficient coverage and an ability to estimate key parameters from each class. The original sampling approach adopted in 1978 means that the dataset collected was not directly representative of the GB landscape. At the time, national estimates were produced using design-based approaches that utilised estimated means and standard errors for each Land Class which were then combined alongside weights accounting for the land class coverage in the overall population (i.e. the land area across GB) to produce an estimated mean (with standard error). As described and well documented previously in Annex F of Emmett et al. 2010, the method of combination involved “weighting the individual land class estimates by values

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



proportional to the area of land within the Land Class. This procedure makes minimal assumptions about the form of the data."

The analytical approach used in contemporary analyses (Scott et al. 2008, Emmett et al. 2010, Bentley et al. 2025) ensures that estimates for the national mean in 1978 and 1998 are corrected for that bias, to reflect the composition of the larger dataset, which is nationally representative (i.e., Land Classes sampled proportionally to area). This is done by incorporating a temporal autocorrelation structure that accounts for plot and square identity. This structure accounts for the square level influence that would occur in each survey relative to the full sample set (from 2007 onwards), thus dampening any bias caused by missing survey squares in one survey compared to any other. This structure is used to inform the overall national mean estimates of stock and change. This also ensures that model derived estimates of stock and change are consistent with one another (Scott et al. 2008 and Emmett et al. 2010 and see FAQ h). The modelling approach maximises the use of all available data and exploits the representative sampling structure implemented in 2007 onwards. The impact of the new methodology was tested extensively in the 2007 analyses (and reviewed in Kirk et al., 2011), whereby every national estimate of stock and change was produced using multiple approaches to specifically check that no bias was introduced (Annex F in Emmett et al. 2010). Fundamentally, the mixed model-based approach was compared to using design-based inference (as adopted in 1978) on those squares surveyed in each campaign. As suspected, based on the model structure adopted, no bias was found between the different approaches.

Although estimates of the mean for 1978 and 1998 will not be biassed in our analyses, the reduced sample size does mean that inference from those years is more limited. In this approach, there is also an assumption that the changes we detected from 1978 to 1998 and 2007 were representative of wider changes from the sites not monitored in those initial years. Given the wide range of sites that were captured in the initial monitoring, we believe this assumption is reasonable.

j) What impact does short-range variation in soil properties have on the national trend analyses?

There are three sources of short-range variation in the soil sampling of the Countryside Survey. The first is that the soils sampling is destructive, and therefore it is not possible to resample the exact same soil again. Secondly, short range variation is introduced in the design of the soil sampling at plot scale to avoid disturbance from previous core extractions influencing future measurements: soil cores are collected from the corner of one of the nested quadrats (2x2 m) used for vegetation monitoring, but the corner used is rotated between surveys. As such, there will be approximately 2m between successive sampling points. Thirdly, any fine scale errors in plot relocation will introduce some additional variation to the soil sampling location.

Critically, this short-range variation will add noise to the analysis of soil condition and change over time but will not add bias to the dataset as a whole. To reduce the impact of this noise on analyses, procedures are in place to optimise plot relocation as previously described.

k) How have soil analysis methods changed over time in the Countryside Survey?

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

Open Access Earth System Science Data Discussions

The history of soils monitoring up to 2007, as it pertains to the analysis in the main text, is summarised in the main text with additional detail in the supplement above. A more detailed description is provided in Emmett et al (2010) and Emmett et al. (2008). A brief timeline is provided below:

- Re-analysis of 1998 LOI in 2007: In CS2007 a difference between the laboratory procedures used to measure LOI in CS 1978 and CS1998 was identified that may have cause a small bias between the two datasets. Therefore, all samples collected in 1998 were reanalysed using the exact procedure used in 1978, along with the samples from 2007. This data produce with a consistent methodology has been used going forward.
- Measurement of total carbon: Loss-on-ignition (LOI) is a simple and inexpensive method for determining soil organic matter, and SOC using an appropriate conversion equation and was first measured in 1978. However, in 1998 measurements of total carbon using an elemental analyser were also explored. Because measurements of total carbon were not available in 1978, LOI is used for long term trend reporting. In addition, samples for total Carbon could not be obtained for all samples in 2007, making it a less appropriate metric for national status and trend reporting. Therefore, total carbon is principally used to validate the conversion of LOI to SOC as described in the main text.
- Introduction of the measurement of bulk density in CS2007. Further information is available in Emmet et al. (2008), Emmett at al. (2010) and Bentley et al. (2025).
  Furthermore, in 2007 stone volume was measured through water displacement (Emmett et al. 2008), whereas from 2019 onwards, stone volume was calculated from stone mass and an assumed particle density of 2.65 g cm^{-3}, as rates of air nucleation were felt to introduce unsatisfactory rates of error and noise that was not possible to quantify. To determine the effect of this change in method, bulk density for 2007 was recalculated using the mass of stones recorded and an assumed particle density of 2.65 g cm^{-3} and compared to the original measurements. The mean difference in bulk density between the two methods was 0.01 g cm^{-3}, which is considered a minor impact by the CS team and unlikely to impact the majority of applications. Regardless, an updated calculation of bulk density for 2007 is in the process of being publicly released at the time of writing to eliminate this issue.
- Change in instrument used to measure loss on ignition. This change and the rationale behind it is described in Bentley et al. (2025).

l) Why does the Countryside Survey not use bulked soil samples?

Bulking soil samples is a standard procedure to reduce the variance of field scale soil sampling on repeat measures, effectively averaging out short-range heterogeneity in soil properties (Lark 2012). The benefits of this methodology are 1) reduced noise on resampling for a specific site and 2) the bulked sample is more representative of the site in question, compared to a single core. However, bulking soil samples can also obscure the relationships between different metrics (e.g. pH, N, SOC), particularly when those relationships are non-linear, by effectively averaging each measurement across multiple samples.

CS uses a single-core per plot approach, rather than a bulked sampling approach because: 1) The impact of bulking soil samples on co-located metrics would hinder our ability to understand the relationships between different soil metrics, co-located vegetation metrics and the drivers of change, which is one of the fundamental objectives of the survey; and 2) The

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



755 monitoring program is not aiming to comprehensively sample the sites around each plot, as it is an audit of national condition as a whole. As such, greater levels of variation at plot scale are acceptable as long as the number of replicates per land class and across the sampling design can provide sufficient power.

Table A1 Additional resources previously published by the CS that address frequently asked questions about the
760 monitoring design and analytical approach used in the main text. Questions and resources are grouped by topic. These questions are addressed in brief in the main text where appropriate, but resources have been consolidated here along with the additional discussion below.

	Question	**Supporting resources**
Topic: Monitoring design and sampling strategy		
a	What are the design principles behind the Countryside Survey?	*Robinson et al. (2024)* *Kirk et al (2011)* *Scott et al (2008)* *Black et al (2008)*
b	Why use a stratified random sampling design?	*Kirk et al (2011)* *Scott et al (2008)*
c	What are the ITE land classes?	*Barr & Wood (2011)* *Bunce et al. (1990)* *Bunce et al. (1996)* *Bunce et al. (2007)* Datasets available on the EIDC
d	How is the sampling frequency per land class decided?	*Barr & Wood (2011)*
e	How has the sampling effort in the Countryside Survey changed over time?	*Barr & Wood (2011)* *Wood et al. (2018)*
f	How does the design of the survey account for changing research questions that might be asked of it whilst retaining the integrity of long-term monitoring and analysis?	*Robinson et al. (2024)* *Barr & Wood (2011)*
g	How are plots relocated and how accurate is plot relocation?	*Wood et al. (2018)* *Prosser and Wallace (2008)*

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Topic: Accounting for changes to sample size and design in analysis		
h	How does variable access to plots in the field impact analyses of national trends?	Annex F of *Emmett et al. (2008).* *Scott et al. (2008)* *Kirk et al (2011)*
i	How does the change in ITE land class system and sampling effort in 2007 impact national trend analyses?	Annex F of *Emmett et al. (2008).* *Scott et al. (2008)* *Kirk et al (2011)*
j	What impact does short-range variation in soil properties have on the national trend analyses?	Annex F of *Emmett et al. (2008).* *Scott et al. (2008)* *Kirk et al (2011)*
Topic: Soil sample measurement and processing		
k	How have soil analysis methods changed over time in the Countryside Survey?	*Emmett et al (2010)* *Emmett et al (2008)*
l	Why does the Countryside Survey not use bulked soil samples?	*Robinson et al. (2024)* *Kirk et al. (2011)*

765

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

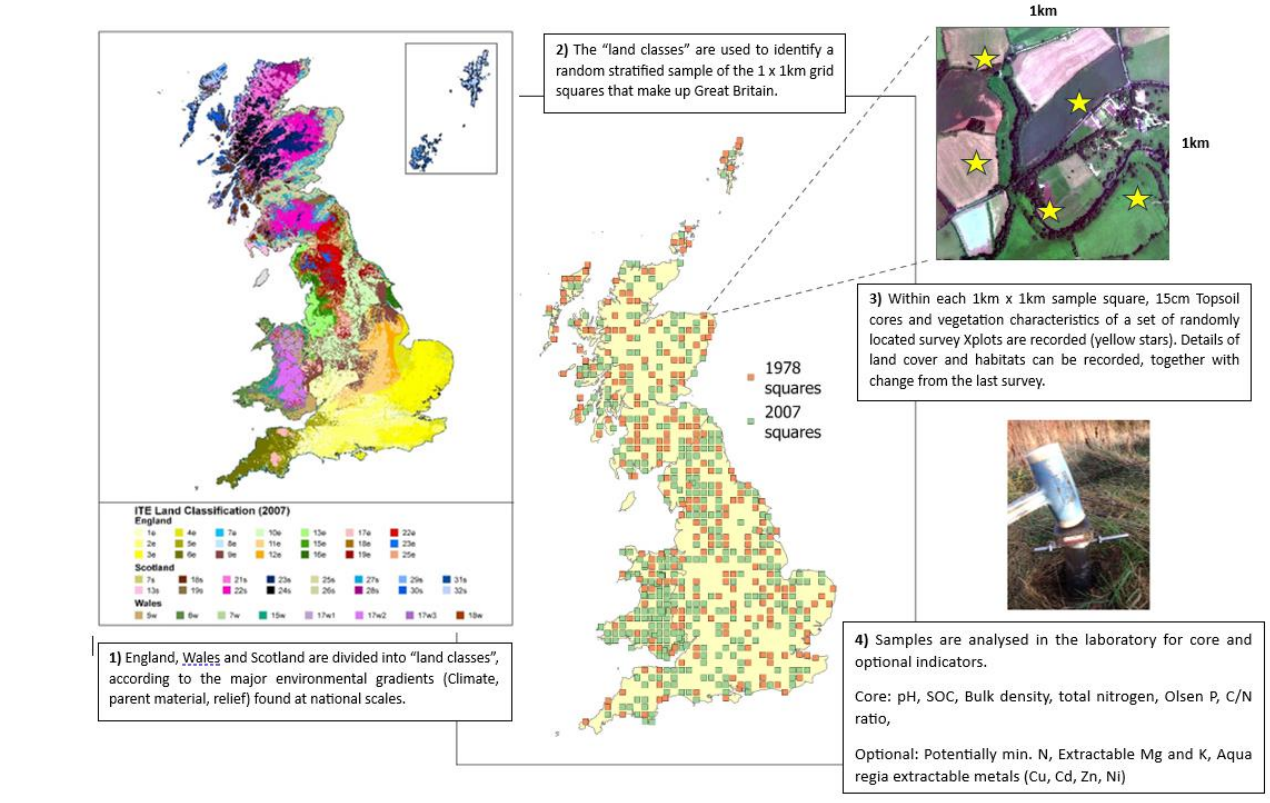


Figure A1 the overarching CS design, from strata to random stratified monitoring squares where samples are taken to have indicators measured. In 1978, 256 squares were selected for sampling; this increased in subsequent monitoring to a maximum of 591 in 2007, with the current rolling program ~500. Replicated from Robinson et al. (2024).

770

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Appendix B - Land Class and Environmental Zones

ITE Land Class 2007 of Great Britain is used as the basis for stratifying the survey (Table B.1). 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 B.1 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	England	Low calcareous hills / variable lowlands, S England
3e	England	Flat / gently undulating plains, E Anglia / S England
4e	England	Flat coastal plains, E Anglia / S England
5e	England	Shallow slopes / floodplains, S-W England
6e	England	Complex valley systems / table lands, S-W England
7e	England	Sea cliffs / hard coast, England
8e	England	Estuarine / soft coast / tidal rivers, England
9e	England	Almost flat plains, N Midlands, NE England
10e	England	Gently rolling / almost flat plains, NE England / N Midlands
11e	England	Flat plains / small river floodplains, E Midlands
12e	England	Large river floodplains, flat plains, margins, E Anglia
13e	England	Coastal plains / gently rolling low hills, NW England
15e	England	Flat river valleys / lower hill slopes, NW England
16e	England	Gently rolling low hills / flat river valleys, NW England
17e	England	Upland valleys / rounded hill sides, England
18e	England	Upland valley sides / Low mountains, N England
19e	England	Upland valleys / plateaux, N England
22e	England	Intermediate mountain tops / broad ridges, N England
23e	England	High mountain summits / ridges, N England
25e	England	Flat / gently undulating river valleys, N England
7s	Scotland	Hard / mixed coasts, S-W Scotland
13s	Scotland	Coastal plains / soft coasts, S-W Scotland
18s	Scotland	Isolated hills / mountain summits, W Scotland

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



19s	Scotland	Upland valleys / low mountains, S Scotland
21s	Scotland	Low mountain slopes / upper river valleys, Highlands
22s	Scotland	Round mountains / broad upper ridges, S Scotland / Highlands
23s	Scotland	High mountain summits / ridges / valleys, Highlands
24s	Scotland	Steep valley sides / intermediate mountain tops, W Highlands
25s	Scotland	Undulating plains / gently sloping valleys, E Scotland
26s	Scotland	Flat plains / gently sloping lowlands, central & S Scotland
27s	Scotland	Low hills / undulating lowlands, Scotland except W
28s	Scotland	Shallow valleys / low hill plateaux, throughout Scotland
29s	Scotland	Inner rocky / mixed coasts / complex topography, W Scotland
30s	Scotland	Outer rockery / mixed coasts / low hills, W Scotland / Islands
31s	Scotland	Rocky / mixed coasts / low hills, N Scotland / Islands
32s	Scotland	Shallow hills / complex coastlines, N Scotland / Islands
17w1	Wales	Low mountain ridges / valley slopes, N Wales
17w2	Wales	Rounded mountains / scarps / upper valleys, mid / S Wales
17w3	Wales	Variable landforms of hills / low mountain, Wales
5w	Wales	Shallow slopes / flood plains, Wales
6w	Wales	Complex valley systems / table lands, Wales
7w	Wales	Sea cliffs / hard coast, Wales
15w	Wales	Flat river valleys / lower hill slopes, Wales
18w	Wales	Upland valley sides / low mountains, Wales

Countryside survey Environmental Zones

Environmental Zones are aggregations of ITE Land Classes (Table B.2); 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 B.2 Environmental Zone categorization based on ITE Land Classes (2007).

Environmental Zone 2007	ITE Land Class Numbers (2007)	Environment Zone 2007 description

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



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

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Appendix C – Collaboration between Countryside Survey and ERAMMP

The Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP) was commissioned by the Welsh Government to provide business-critical evidence and expertise through the three interrelated components of Monitoring (the National Field Survey), Modelling (the Integrated Modelling Platform) and the provision of Evidence and expert advice. The ERAMMP National Field Survey (NFS) ran from 2021-2025, across 300 1km squares in Wales, and is a resurvey of the NFS carried out under the Glastir Modelling and Evaluation Program (2013-2016). Of those 300 squares, 150 were designed to provide a representative sample of the Welsh Countryside, following the same design principles and approach as the Countryside Survey, and based of the 2007 ITE land classes that underpin the current Countryside Survey.

To allow ERAMMP and GMEP data to be used in concert with the historical legacy provided by the Countryside Survey in Wales:

1. It was agreed that the original Countryside Survey squares sampled in 1978 would be included as part of the sample of 150 nationally representative squares in GMEP and ERAMMP. The identity of these squares within the population was shared with Welsh Government subject to a licenced data sharing agreement, to preserve the wider anonymity of Countryside Survey and GMEP/ERAMMP squares.
2. Soil monitoring protocols in the field and laboratory were kept identical to those used in the Countryside Survey. Data sets were subject to the same QA processes. Soil monitoring programs were overseen and managed by UKCEH teams that included the same individuals for both GMEP, ERAMMP and Countryside Survey to ensure continuity between the two programs. This includes protocol design, training delivering, data QA and preparation for publication. All data was processed in the same laboratories by the same staff and equipment. As such, the ERAMMP and Countryside survey datasets are considered directly comparable for key soil condition indicators (published or publication in progress), including:

    - Loss on ignition
    - Carbon concentration
    - Carbon stock
    - Bulk density
    - pH
    - pH in $CaCl_2$
    - Electrical conductivity
    - Volumetric & Gravimetric Moisture Content
    - Total Carbon
    - Total Nitrogen
    - Olsen Phosphorous
    - Total Phosphorous
    - Organic matter depth

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.


For additional metrics, and additional detail on the specifics of ERAMMP, users should consult the information provided with the respective datasets.

Impact on Countryside Survey 2019-2023 data

As a result of this collaboration, and the cross-compatibility of datasets, it was decided that the 1978 Countryside Survey squares would not be resurveyed as part of the Countryside Survey in the 2019-2023 monitoring cycle - this data would instead be collected and made available under an Open Governmental Licence via ERAMMP.

The reasons for this decision were:

1. To minimise costs that would be associated in duplicating the datasets
2. To reduce the impact on landowners associated with two independent survey visits.

Therefore, in order to capture the full nationally representative sample of Wales and Great Britain for analysis of Countryside survey data, some ERAMMP data is contained within the published data for the Countryside Survey for the latest monitoring cycle. The full ERAMMP dataset can be accessed from the Environmental Information Data Centre in Reinsch et al. (2025) at doi.org/10.5285/deabe608-fc6e-4d3a-812f-fb08ae51512.1.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Appendix D - Data collection methods

General field methods are described in Emmett et al. (2008) and Robinson et al. (2023). At each pre-defined location, five soil samples are taken, sent to UKCEH sites for processing or storage. Processed, airdried and frozen soil samples are stored in the UKCEH Soil Bank.

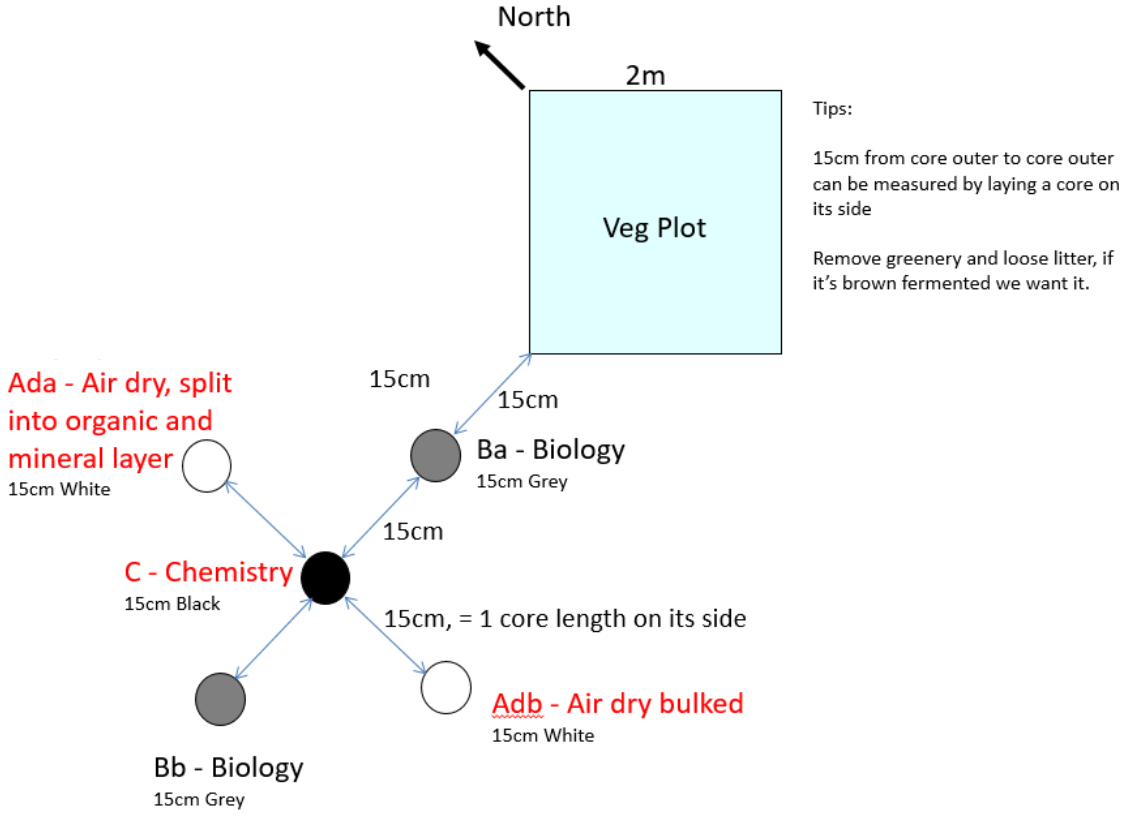


Figure D.1 Soil sample plot layout, reproduced from Robinson et al. (2023). The 2 m x 2 m quadrat of the vegetation plot is show, along with the relative positioning of the topsoil cores in the 2019-23 monitoring cycle. The two biological cores (Ba and Bb - grey) are collected and returned to the archive in Lancaster and frozen at -20°C. Ada and Adb (white) are collected and dried and stored. Core C (black) is the core that is analysed for regularly reported physicochemical metrics.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



3) Corer
4) Handle
5) Metal cap
6) Hammer block
7) Crossbar

Figure D.2 Countryside Survey soil corer, picture reproduced from Robinson et al. (2023), showing the metal corer body with the cutting shoe (3), handle (4) and cap (5). The cross bar (7) attaches the handle to the top of the corer and prevents the corer entering more than 15cm intro the soil. The hammer block (6) can be optionally used to prevent bounce-back and reduce damage to the corer over time when hammering into the soil.

Table D1 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 for soils	Number of soil samples analysed
1978	Centre	256	1284
1998	15 cm to North	256	1284
2007	15 cm to South	591	2955
2018 2019	15 cm to West	6 100	25 456
2020	15 cm to West	48	196
2021	15 cm to West	110	493
2022	15 cm to West	110	464
2023	15 cm to West	149	597

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Appendix E - Countryside Survey datasets

Table E1 Soil indicator and ancillary soil data in the CS database. The total number of samples and squares indicate the number of samples collected and number and squares planned in the field survey. This may differ slightly to the number of samples and squares with metrics reported in the data, due to possible sample or measurement loss, and logistical challenges of the field survey, including potential unsafe sampling conditions in the field preventing sample collection, and possible urbanisation soil sealing preventing sample collection. Not all samples in a given year are repeats of a given sample, due to relocation inaccuracies, therefore resampled populations may be smaller than the total sample size given. A grey cell indicates that no data exists for that metric / year. References (Ref), indicating where to access each dataset are provided below.

Ref	Dataset \ Year	1978	1990	1998	2007	2018/ 2019	2020	2021	2021 winter survey	2022	2023	Notes
-	Number of CS squares	256	501	569 (256 for soil)	591	6/102	49	110	146	110	149	2020 was low due to Covid19. 2018 was a pilot year.
-	Max. potential plots surveyed for soils	1284	0	1284	2955	30/510	245	550	730	550	745	
-	Number of samples taken	1284	0	1284	2955	25/456	196	493	583	464	597	
Soil type/structure												
1	Soil structure, colour, horizons	1265										Not currently for general release
1	Countryside Survey soil maps (Soil series, Avery codes)		501									Mapped for 1km squares, not for general release
4-10	Bulk density				2570	25/456	193	514	571	464	637	
1,11	Texture Sand, Silt &				1103	313	165	329		329	639	2007 texture not

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



	Clay											published. Used a hand texturing method Texture 2019-2023 using laser for samples with organic matter < 40%
12	Aggregate stability				419							Arable and improved grassland only
11	Aggregate size (Laser)					456						
1	O horizon depth	1265				25/456	193	510		464	639	A rod is used to estimate the depth of O horizon. Not currently for general release.
Chemical analyses												
2-10	pH in water 1:2.5	1224		1106	2644	25/456	193	514	571	464	637	Field moist sample
1	pH in CaCl2 1:2.5				2644	25/456	193	513	571	464	637	Not currently for general release.
11	Electrical					25/456	193	515	571	463	637	

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



	Conductivity 1:2.5											
2-10	Soil Organic Matter (SOM) Loss on ignition	1197		1098	2614	25/456	193	515	571	463	637	
1, 11	Total Carbon content (%)			1094	1020	25/456	193	515	571	463	637	Not released for 1998 or 2007. Patial survey in 2007. Published for 2019-2023
3-10	Moisture content			1098	2614	25/456	193	515	571	463	637	Gravimetric and volumetric
5-10	Hygroscopic water content					25/456	193	514	571	463	637	Gravimetric
16	Mineralisable Nitrogen				699							Subset
1	Mineralisable Carbon				686							Not currently for general release.
1	N core Leachate analyses				703							Not currently for general release.
3-10	Nitrogen %			1084	1004	23/456	193	513	255	464	637	
3-10	Olsen Phosphorus			925	1044	8/196	55	178	0	166	268	Only in arable and improved grass from 2019 onwards

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

5-10	Total Phosphorus					22/453	193	503	0	463	636	
1	Persistent organic pollutants			200								Subset
14-15	Arsenic, mercury			108	402							Subset
14-15	Heavy metals (Cd, Cr, Cu, Ni, Pb, V, Zn. 2007 only: Li, Be, Al, Ti, Mn, Fe, Co, Rb, Se, Sr, Mo, Sb, Sn, Cs, Ba, W, U, P, S)			1093	402							Subset in 2007
Soil fauna												
16-17	Soil invertebrates			1064	921							Summary indicators
1	Soil collembola species			336								Subset
18	Oribatid mite species			507								Subset
1	Protozoa			59								Subset
Microbiology												
1	BIOLOG data			970								
19	Amplicon Sequencing: Fungi - ITS regions				1113							
19	Amplicon Sequencing: 18S rRNA				1113							
19	Amplicon Sequencing: Soil bacterial - 16S rRNA				1113							
20	TRFLP data				1011							Data stored

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



												in GENBANK (https://www.ncbi.nlm.nih.gov/nucleotide/). Accession IDs provided in reference
Function indicators												
21	dissolved organic matter (DOM)				304							Subset
21	soluble N				304							Subset
21	reduced N				304							Subset
21	microbial biomass				304							Subset
21	metabolic quotients				304							Subset
21	microbial quotients				304							Subset
21	DOM humification				304							Subset
21	Soil respiration				304							Subset
100 samples												
22	SOM, POM & MOAM					69	31					Subset
23	Metagenomes					69	31					Subset
Spectroscopy												
24	Mid-infrared spectroscopy data				427							Subset: cropland and grassland
25	Vis-NIR (ASD Agric spectrometer)					451						Subset
25	Vis-NIR (FOSS DS2500)					306						Subset

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Additional information												
1	**Soil sampling dates**	**ü**		**ü**	**ü**	**ü**	**ü**	**ü**	**ü**	**ü**	**ü**	**Limited information available in earlier years.**
1	**Site locations**	**ü**	**ü**	**ü**	**ü**	**ü**	**ü**	**ü**	**ü**	**ü**	**ü**	**Confidential**

Data publication references

1. Held internally at UKCEH. Not publicly released.
2. Bunce, R.G.H.; Hornung, M.; Hatton, A.; Stevens, P.A.; Cummins, R.; French, D. (2016). Soil physico-chemical properties 1978 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/85c71959-0f7c-4f04-b3a7-152673107a85
3. Black, H.I.J.; Chaplow, J.S.; Ainsworth, G.; Coward, P.A.; Creamer, R.; Ellwood, S.; Horne, J.; Hornung, M.; Kennedy, V.H.; Raine, L.; Osborn, D.; Parekh, N.R.; Parrington, J.; Poskitt, J.M.; Potter, E.; Reeves, N.; Rowland, A.P.; Self, P.; Turner, S.; Watkins, J.W.; Wood, C.M.; Woods, C.; Wright, J. (2016). Soil physico-chemical properties 1998 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/9d1eada2-3f8b-4a7b-a9b0-a7a04d05ff72
4. 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.M.; Woods, C. (2016). Soil physico-chemical properties 2007 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/79669141-cde5-49f0-b24d-f3c6a1a52db8
5. Bentley, L.; Brentegani, M.; Andrews, C.; Brown, K.; Cope, S.; Ebuele, V.; Emmett, B.A.; Fitos, E.; Friend, R.; Garbutt, R.A.; Gray, A.; Hancock, G.; Henrys, P.A.; Higgins, A.; Keenan, P.; Keith, A.M.; Lebron, I.; Moscrop, A.; O'Brien, L.; Pallett, D.W.; Pereira, M.G.; Reinsch, S.; Risser, H.; Rowe, R.L.; Scarlett, P.; Smart, S.M.; Tandy, S.; Towill, J.; Wagner, M.; Wood, C.M.; Robinson, D.A. (2024). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2023. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/fe58d52e-f00c-4895-a35e-26b7353cc275
6. Reinsch, S.; Bentley, L.; Brentegani, M.; Chetiu, N.; Dhiedt, E.; Emmett, B.A.; Fitos, E.; Garbutt, R.A.; Guyatt, H.; Henrys, P.A.; Hunt, A.; Keenan, P.; Keith, A.M.; Lebron, I.; Mensah, E.; Pallett, D.W.; Pereira, M.G.; Risser, H.; Rowe, R.L.; Salisbury, E.; Scarlett, P.; Smart, S.M.; Tandy, S.; Wagner, M.; Wallace, H.; Wood, C.M.; Robinson, D.A. (2023). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2022. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/d53fdf1d-767a-4046-821a-ea645001ddd3
7. Bentley, L.; Reinsch, S.; Brentegani, M.; Chetiu, N.; Dhiedt, E.; Emmett, B.A.; Fitos, E.; Garbutt, R.A.; Guyatt, H.; Henrys, P.A.; Hunt, A.; Jackson-Bue, M.; Keenan, P.; Keith, A.M.; Lebron, I.; Pallett, D.W.; Pereira, M.G.; Risser, H.;

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

Rowe, R.L.; Scarlett, P.; Smart, S.M.; Tandy, S.; Wagner, M.; Wallace, H.; Wood, C.M.; Robinson, D.A. (2023). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2021. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/af6c4679-99aa-4352-9f63-af3bd7bc87a4

8. Bentley, L.; Reinsch, S.; Dhiedt, E.; Henrys, P.A.; Emmett, B.A.; Risser, H.; Tandy, S.; Lebron, I.; Brentegani, M.; Garbutt, A.; Wood, C.M.; Robinson, D.A. (2024). Winter topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2021. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/38d6f5b4-4d03-4006-aa55-91894378ef27
9. Bentley, L.; Reinsch, S.; Alison, J.; Brentegani, M.; Chetiu, N.; Dhiedt, E.; Emmett, B.A.; Fitos, E.; Garbutt, R.A.; Guyatt, H.; Henrys, P.A.; Hunt, A.; Keenan, P.O.; Keith, A.M.; Lebron, I.; Long, C.; Meek, B.; Millani Lopes Mazzetto, J.; O'Rourke, C.; Pallett, D.W.; Pereira, M.G.; Pinder, A.; Risser, H.; Rowe, R.L.; Scarlett, P.; Seaton, F.; Smart, S.M.; Wagner, M.; Wallace, H.; Wood, C.M.; Robinson, D.A. (2023). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2020, v2. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/6a3382cc-f5f4-4d68-9517-c62fadd8af4f
10. Bentley, L.; Reinsch, S.; Alison, J.; Andrews, C.; Brentegani, M.; Chetiu, N.; Dart, S.; Dhiedt, E.; Emmett, B.A.; Fitos, E.; Garbutt, R.A.; Gray, A.; Henrys, P.A.; Hunt, A.; Keenan, P.O.; Keith, A.M.; Koblizek, E.; Lebron, I.; Millani Lopes Mazzetto, J.; Pallett, D.W.; Pereira, M.G.; Pinder, A.; Risser, H.; Rose, R.J.; Rowe, R.L.; Scarlett, P.; Seaton, F.; Smart, S.M.; Towill, J.; Wagner, M.; Williams, B.; Wood, C.M.; Robinson, D.A. (2023). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2018-2019. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/821325f3-b353-4a51-8db2-6b2200d82aca
11. Lebron, I.; Ebuele, V.O.; Brentegani, M.; Tandy, S.; van Soest, M.; Garbutt, A.; Bentley, L.; Williams, B.; Wood, C.M.; Emmett, B.A.; Robinson, D.A. (2025). Topsoil particle size distribution, electrical conductivity, calcite and total carbon from the Countryside Survey of Great Britain for 2018-2023, and aggregate information for 2019. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/6893097f-f504-4b77-96c8-8daa5da6a09d
12. Keith, A.M.; Cave, M.R.; Dodd, B.A.; Smart, S.M.; Turner, G.; Tye, A.M.; Wood, C.M. (2020). Soil aggregate stability data from arable and grassland in Countryside Survey, Great Britain 2007 . NERC Environmental Information Data Centre. https://doi.org/10.5285/be3793b6-90fb-4e4c-9515-220cc33223b9
13. 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.M.; Woods, C. (2016). Topsoil mineralisable nitrogen (mineral-N) data 2007 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/3bafb72b-9f2a-4cbc-a7b8-46e3731c6759
14. 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.M.; Woods, C. (2016). Soil metals data 2007 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/826b0829-7ab5-4e22-822f-ee3a137896a9

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



15. Black, H.I.J.; Chaplow, J.S.; Ainsworth, G.; Coward, P.A.; Creamer, R.; Ellwood, S.; Horne, J.; Hornung, M.; Kennedy, V.H.; Monson, F.; Raine, L.; Osborn, D.; Parekh, N.R.; Parrington, J.; Poskitt, J.M.; Potter, E.; Reeves, N.; Rowland, A.P.; Self, P.; Turner, S.; Watkins, J.W.; Wood, C.M.; Woods, C.; Wright, J. (2016). Soil metals data 1998 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/def15f47-6aba-43db-a833-5844628a658b

16. Black, H.I.J.; Chaplow, J.S.; Creamer, R.; Hornung, M.; Monson, F.; Poskitt, J.M.; Potter, E.; Self, P.; Watkins, J.W.; Wood, C.M. (2016). Soil invertebrate data 1998 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/f3e71ba6-bfd7-4841-9ce4-fd1f0d590d2d

17. Emmett, B.A.; Reynolds, B.; Chamberlain, P.M.; Rowe, E.; Spurgeon, D.; Brittain, S.A.; Frogbrook, Z.; Hughes, S.; Keith, A.M.; Lawlor, A.J.; Monson, F.; Poskitt, J.; Potter, E.; Robinson, D.A.; Scott, A.; Thompson, N.; Watts, R.; Wood, C.M.; Woods, C. (2016). Soil invertebrate data 2007 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/fccd86b0-f5b6-4716-b4f7-f43ad82daeee

18. Keith, A.M.; Monson, F.D.; Chaplow, J.S.; Black, H.I.J.; Self, P.; Rollett, A.; Wood, C.M. (2018). Oribatid mites 1998 [Countryside Survey] . NERC Environmental Information Data Centre. https://doi.org/10.5285/05cae9ae-86c4-4a2f-a628-6c7fd0882459

19. Centre for Ecology & Hydrology. (2021). British soil microbial communities from UKCEH Countryside Survey (PRJEB45286). European Nucleotide Archive. https://www.ebi.ac.uk/ena/browser/view/PRJEB45286

20. 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: 1642-1654. https://doi.org/10.1111/j.1462-2920.2011.02480.x

21. Simfukwe P, Hill PW, Emmett BA, Jones DL (2021) Identification and predictability of soil quality indicators from conventional soil and vegetation classifications. PLOS ONE 16(10): e0248665. https://doi.org/10.1371/journal.pone.0248665

22. Lebron, I.; Reinsch, S.; Bentley, L.; Cosby, B.J.; Emmett, B.A.; Keenan, P.; Pereira, G.; Robinson, D.A. (2025). Carbon and nitrogen contents of soil organic matter fractions, soil organic carbon, total soil nitrogen, and soil organic matter of 100 topsoil samples from the UKCEH Countryside Survey, Great Britain, 2019-2020 v2. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/29cd5386-bc2e-4d70-a6a5-0d7dc7513dc

23. Centre for Ecology & Hydrology. (2024). GB Countryside Survey 2019/2020 soil microbial data (PRJEB75011). European Nucleotide Archive. https://www.ebi.ac.uk/ena/browser/view/PRJEB75011

24. Keith, A.M.; Dodd, B.A.; Turner, G.; Vane, C.H.; Wood, C.M. (2020). Soil mid-infrared spectroscopy data from arable and grassland in Countryside Survey, Great Britain 2007. NERC Environmental Information Data Centre. https://doi.org/10.5285/d66ca0a6-403d-4f5a-bef1-8ee177f1e1b3

25. Ebuele, V.O.; Tandy, S.; Brentegani, M.; Lebron, I.; Tye, A.; Keith, A.; Hermansen, C.; Wollesen de Jonge, L.; Zaresourmanabad, M.; Robinson, D.A. (2025). Topsoil visible and near-infrared (Vis-NIR) spectral data from the

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



UKCEH Countryside Survey, Great Britain, 2018-2019. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/ea727f8d-6441-4d88-8ed7-1760bda0c3c3

975

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Appendix F Additional data descriptions

F1. Soil Texture

The particle size distribution was assessed using a laser diffraction instrument (Beckman Coulter LS13 320). Soil samples were pretreated to remove organic matter; however, no pretreatment was performed for the elimination of $CaCO_3$. This decision was based on the fact that the $CaCO_3$ found in UK soils primarily originates from the parent material in England, rather than from evaporative pedogenic processes (Kerry et al., 2009; Rawlins et al., 2011). Soils with greater than 40% organic matter were not analysed. Internal soil standards were utilized to ensure accuracy, and 10% repeats were conducted to verify precision. Additionally, the sand fraction was collected at the conclusion of the measurement using a 63 µm sieve for comparison with the sand fraction obtained through laser measurement. Since 2019, we have been participants in the internationally accredited soils testing scheme WEPAL. Soils of varying textures are routinely analysed, and the results are submitted for evaluation regarding precision and accuracy. Data generated in our laboratory demonstrate consistent agreement with those provided by WEPAL (Lebron et al., 2025). Soils from Great Britain are situated along the central area of the soil texture triangle, consistent with other published data, where sand, silt, and clay are more evenly distributed, ranging from sandy loam to silty loam in most agricultural regions. There are regional trends indicating heavier clay soils in the western areas and more clay loam in the Midlands and southern regions of England.

References

Kerry, R., Rawlins, B.G., Oliver, M.A. and Lacinska, A.M., 2009. Problems with determining the particle size distribution of chalk soil and some of their implications. *Geoderma*, *152*(3-4), pp.324-337.

Lebron, I.; Ebuele, V.O.; Brentegani, M.; Tandy, S.; van Soest, M.; Garbutt, A.; Bentley, L.; Williams, B.; Wood, C.M.; Emmett, B.A.; Robinson, D.A. (2025). Topsoil particle size distribution, electrical conductivity, calcite and total carbon from the Countryside Survey of Great Britain for 2018-2023, and aggregate information for 2019. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/6893097f-f504-4b77-96c8-8daa5da6a09d

Rawlins, B.G., R. Webster, A.M. Tye, R. Lawley, and S.L. O'Hara. 2009. Estimating particle-size fractions of soil dominated by silicate minerals from geochemistry. European J. of Soil Sci. 60:116-126.

F.2 eDNA: Amplicon Sequencing – CS2007

Soil samples were collected across Great Britain as part of the 2007 UKCEH Countryside Survey (Emmett et al., 2010; Simfukwe et al., 2021). DNA was extracted from 0.3 g soil using the MoBIO PowerSoil-htp 96-well kit. Amplicons targeted bacterial 16S rRNA genes (341F/806R; Caporaso et al., 2011), fungal ITS regions (fITS7/ITS4; Ihrmark et al., 2012), and eukaryotic 18S rRNA genes (EukA7F: Medlin et al., 1988; Euk570R: Weekers et al., 1994). Libraries were sequenced on the Illumina MiSeq platform (2 × 300 bp), and raw reads are available via ENA accession PRJEB45286. Sequences were processed using DADA2 (Callhan et al 2016) to generate amplicon sequence variants (ASVs). The 18S dataset was partitioned into protist and metazoan groups prior to further analysis. ASV tables were rarefied to 5,000 reads for bacteria and fungi, 2,000 reads for protists, and 300 reads for metazoa. Observed ASV richness was calculated and summarised

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



across broad habitat categories. Habitat type is a strong determinant of within-group ASV richness, with clear and consistent differences across the broad habitat categories. Managed systems (e.g. arable and improved grassland) tend to show higher richness of microbial groups (Bacteria, Fungi, Protists) compared with semi-natural habitats such as heath, bog, and woodland, reflecting underlying differences in vegetation, soil properties, and disturbance regimes. For metazoans, there is reduced richness in more intensively managed habitats, with higher richness typically observed in less disturbed systems. As seen in morphological analysis of Orbatid mites in the countryside survey (Pravia et al. 2025) land-use intensity and associated environmental pressures disproportionately constrain metazoan diversity relative to other soil biota. The same pattern was observed in molecular data by George et al. (2019) for the ERRAMP Welsh soil survey.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Appendix G – Quality Assurance Process

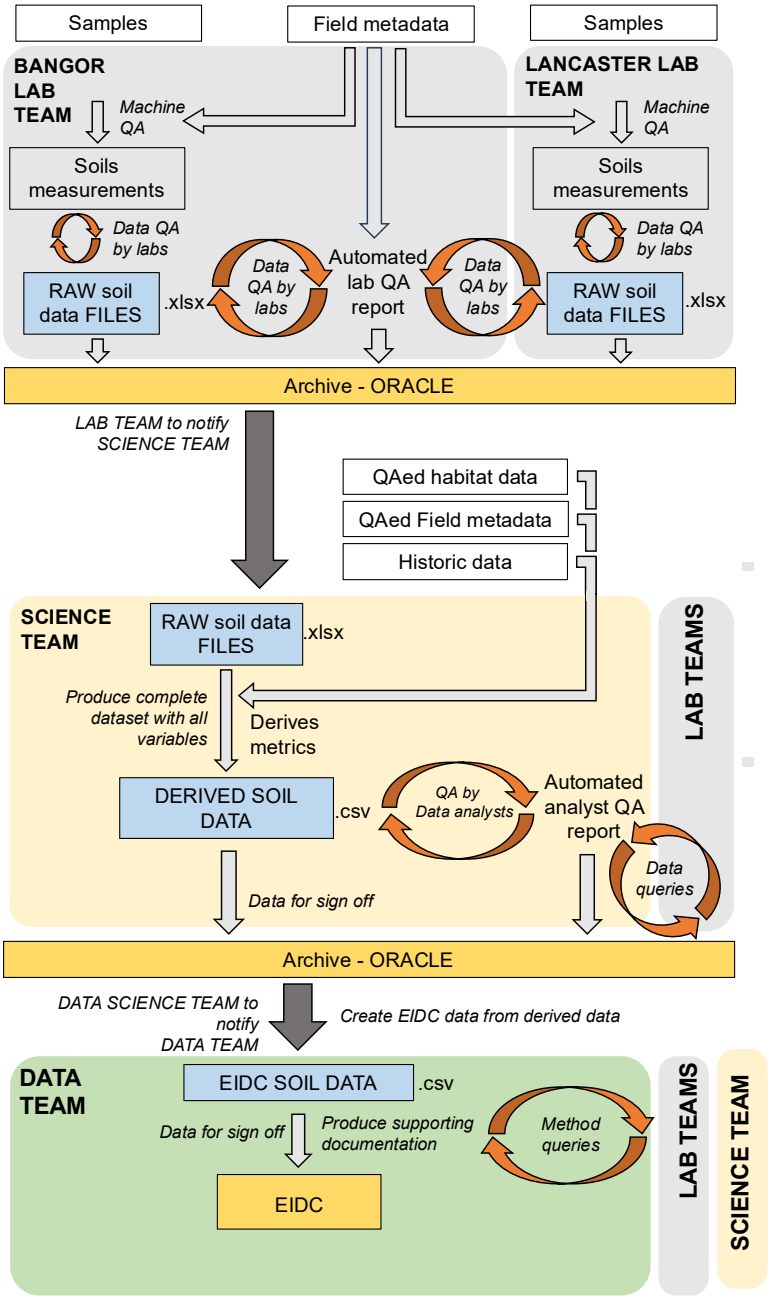


Figure G1 Lab and data QA process in the Countryside Survey, carried out on receipt of samples from the field. Orange arrows indicate a QA cycle where various data quality checks are carried out that may result in relevant samples being reanalysed in the lab to verify values. All data is version controlled during this process and changes are logged.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Open Access Earth System Science Data Discussions

Appendix H - Location Sharing Policy

The aim of this policy is to maximise the utility of Countryside Survey (CS) spatial data in the public interest whilst minimising the risk of compromising future surveys and anonymity of the site locations which would not be in the public interest. The policy only relates to survey square location data and spatial data within survey squares.

Why are the locations of CS squares considered to be confidential?

CS square locations are considered confidential to preserve the representativeness of sampling sites and the goodwill of landowners. These are both essential elements to the future of the survey to ensure the scientific integrity of the sampling strategy, the protection of the environment, and help to ensure future permission from landowners to survey their land. Future surveys would be compromised if either of these elements were to be jeopardised and our capacity to reliably inform environmental policy would be diminished.

We believe our position on confidentiality to be in the public interest. Any requests for this information will be dealt with by UKCEH, on behalf of NERC and the CS partners, under the terms of the UK Freedom of Information Act 2000 (The Act) or the associated Environmental Information Regulations 2004 (The Regulations).

Under what circumstances may locations be released and at what level of precision?

Survey Data access allows users to identify whether or not any survey squares fall within certain predetermined areas (Country, County, ITE Land Class or Environmental Zone). In circumstances where the approximate locations of survey squares is valuable to users of the data, four-digit grid references can be released under licence allowing users to identify in which 10 km x10 km grid square each square is located.

In circumstances where precise location data (six-digit grid references) are essential to the needs of an external user, it is our policy to ask if pre-processing analysis required can be carried out by UKCEH to avoid the need to release the locations. However, in VERY EXCEPTIONAL circumstances, we may agree to provide location information externally under licence. To qualify for this exceptional access the requesting organisation must demonstrate in legal terms that the Intellectual Property (data, models, etc) to be used with the CS data is considered to carry an equal or higher level of confidentiality/protection than the CS data and therefore cannot be released to UKCEH for processing alongside the CS data. Spatial data from within survey squares (e.g. maps of habitats, linear features) could be used relatively easily to identify the location of a square. It is therefore considered to carry equivalence to the location data and will only be released under the same exceptional circumstances and terms as the six-digit grid references location data.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Sample availability

To enquire about accessing material in the UKCEH soil bank, the soil bank can be contacted directly (uksoilbank@ceh.ac.uk

Team list

Laura Bentley, Claire M. Wood, Chris Feeney, Sabine Reinsch, Angus Garbutt, Susan Tandy, Inma Lebron, Amy Thomas, Maud van Soest, Victor Ebuele, James Lucas, M. Gloria Pereira, Patrick Keenan, Joe D. Taylor, Briony Jones, Lindsay Maskell, Pete Henrys, Simon Smart, Bronwen Williams, Aidan M. Keith, Fiona Seaton, Lisa Norton Bridget A. Emmett, David A. Robinson

Author contribution:

DAR conceptualized the paper. LB wrote the paper; all other co-authors were involved with writing, reviewing and editing the manuscript. LB, DAR, SR, CW, ST, IL, VE, MGP, PK, AK and BAE are or have been directly involved in the management, data production and data quality assurance of the Countryside Survey soils data. AG, LM, PH, SS, BW and LN are or have been directly involved in the wider running of the integrated monitoring by the Countryside Survey.

Competing interests:

The authors declare that they have no conflict of interest.

Acknowledgements

The authors would like to acknowledge and thank the many people who have driven, supported and stewarded the Countryside Survey over its 50 years. Whilst there are too many individuals to name explicitly in the long list of people required to operate a national survey for 50 years, we would particularly like to extend our sincere gratitude to the researchers who have led on the soils program and analysis of the Countryside Survey soils data in the past, including but not limited to Mike Hornung, Paul Stevens, Brian Reynolds, Helaina Black and Paul Chamberlain. We also wish to acknowledge the labours and commitment of the many field surveyors and laboratory staff (including Aldyth Hatton, Roger Cummins, Don French, Jacky Chaplow, Elaine Potter, Jan Poskitt and Nisha Parekh) who have collect and processed the data, and the landowners who generously allowed access to their land, without any of which this dataset would not exist.

Financial support

The research was funded by the Natural Environment Research Council award to UKCEH for the National Capability for UK Challenges Programme NE/Y006208/1. This project acknowledges funding from the European Union's Horizon Europe research and innovation program under grant agreement No.-101086179; and funding from the UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee [grant number 10053484] as part of AI4SoilHealth.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



References

Avery, B.W., 1973. Soil classification in the Soil Survey of England and Wales. *Journal of Soil Science*, *24*(3), pp.324-338.

Avery, B.W., 1981. Soil classification for England and Wales [higher categories]. Rothamsted Experimental Station.

Avery, B.W. & Bascomb, C.L. (Eds.), 1974. Soil Survey Laboratory Methods. Soil Survey Technical Monograph No. 6, Harpenden, vi + 83 pp.

Ball, D. F. (1964). Loss-on-ignition as an estimate of organic matter and organic carbon in non-calcareous soils. *Journal of soil Science*, *15*, 84–92. https://doi.org/10.1111/j.1365-2389.1964.tb00247.x

Ballabio, C., Panagos, P., Monatanarella, L., 2016. Mapping topsoil physical properties at European scale using the LUCAS database. Geoderma, Volume 261, 2016, Pages 110-123, https://doi.org/10.1016/j.geoderma.2015.07.006.

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)

Barr, C. J., Bunce, R. G. H., Clarke, R. T., Fuller, R. M., Furse, M. T., Gillespie, M. K., Groom, G. B., Hallam, C. J., Hornung, M., Howard, D. C. & Ness, M. J. (1993). Countryside Survey 1990 Main Report. Department of the Environment.

Bell, J.R., Alderson, L., Izera, D., Kruger, T., Parker, S., Pickup, J., Shortall, C.R., Taylor, M.S., Verrier, P. and Harrington, R., 2015. Long-term phenological trends, species accumulation rates, aphid traits and climate: five decades of change in migrating aphids. *Journal of Animal Ecology*, *84*(1), pp.21-34.

Bellamy P.H., Loveland P.J., Bradley R.I., Lark R.M. & Kirk G.J.D. (2005) Carbon losses from all soils across England and Wales 1978-2003. *Nature*, 437, 245-248.

Bentley, L.; Brentegani, M.; Tandy, S.; Ebuele, V.; Deacon, A.; Fitos, E.; Patton, J.; Garbutt, A.; Williams, G.; Wood, C.; Lebron, I.; Robinson, D.; Smart, S.; Maskell, L.; Keith, A.; O'Neil, A.; Henrys, P.; Andrews, C.; Campbell, K.; Doyle, S.; Gray, A.; Hancock, G.; Highfield, C.; Nemeth, K.; Pallett, D.W.; Scarlett, P.; Vallis-Wilks, M.; Wagner, M. (2025). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2024. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/cab9f36c-075e-4359-8781-24a8488641c3

Bentley, L.; Reinsch, S.; Alison, J.; Brentegani, M.; Chetiu, N.; Dhiedt, E.; Emmett, B.A.; Fitos, E.; Garbutt, R.A.; Guyatt, H.; Henrys, P.A.; Hunt, A.; Keenan, P.O.; Keith, A.M.; Lebron, I.; Long, C.; Meek, B.; Millani Lopes Mazzetto, J.; O'Rourke, C.; Pallett, D.W.; Pereira, M.G.; Pinder, A.; Risser, H.; Rowe, R.L.; Scarlett, P.; Seaton, F.; Smart, S.M.; Wagner, M.; Wallace, H.; Wood, C.M.; Robinson, D.A. (2023). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2020, v2. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/6a3382cc-f5f4-4d68-9517-c62fadd8af4f

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Bentley, L.; Reinsch, S.; Alison, J.; Andrews, C.; Brentegani, M.; Chetiu, N.; Dart, S.; Dhiedt, E.; Emmett, B.A.; Fitos, E.; Garbutt, R.A.; Gray, A.; Henrys, P.A.; Hunt, A.; Keenan, P.O.; Keith, A.M.; Koblizek, E.; Lebron, I.; Millani Lopes Mazzetto, J.; Pallett, D.W.; Pereira, M.G.; Pinder, A.; Risser, H.; Rose, R.J.; Rowe, R.L.; Scarlett, P.; Seaton, F.; Smart, S.M.; Towill, J.; Wagner, M.; Williams, B.; Wood, C.M.; Robinson, D.A. (2023). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2018-2019. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/821325f3-b353-4a51-8db2-6b2200d82aca

Bentley, L., Thomas, A., Garbutt, A., Williams, B., Reinsch, S., Lebron, I., Brentegani, M., Keenan, P., Wood, C., Smart, S.M., Henrys, P.A., Cosby, B.J., Emmett, B.A. and Robinson, D.A. (2025), First Signs That National Cropland Organic Carbon Loss Is Reversing in British Topsoils. Eur J Soil Sci, 76: e70131. https://doi.org/10.1111/ejss.70131

Bentley, L., Reinsch, S. & Robinson, D.A. (2025). Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP). ERAMMP Technical Annex 105TA1S7: Wales National Trends and Glastir Evaluation, Supplement-7: Soil Health. Report to Welsh Government (Contract C208/2021/2022) (UK Centre for Ecology & Hydrology Project 08435)

Black, H.; Bellamy, P.; Creamer, R.; Elston, D.; Emmett, B.; Frogbrook, Z.; Hudson, G.; Jordan, C.; Lark, M.; Lilly, A.; Marchant, B.; Plum, S.; Potts, J.; Reynolds, B.; Thompson, R.; Booth, P.. 2008 *Design and operation of a UK soil monitoring network.* Bristol, Environment Agency, 208pp. (CEH Project Number: C03357, Science report SC060073, Product Code: SCHO0908BOMX-E-P)

Black, H.I.J.; Chaplow, J.S.; Ainsworth, G.; Coward, P.A.; Creamer, R.; Ellwood, S.; Horne, J.; Hornung, M.; Kennedy, V.H.; Raine, L.; Osborn, D.; Parekh, N.R.; Parrington, J.; Poskitt, J.M.; Potter, E.; Reeves, N.; Rowland, A.P.; Self, P.; Turner, S.; Watkins, J.W.; Wood, C.M.; Woods, C.; Wright, J. (2016). Soil physico-chemical properties 1998 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/9d1eada2-3f8b-4a7b-a9b0-a7a04d05ff72

Black, H.I.J.; Chaplow, J.S.; Ainsworth, G.; Coward, P.A.; Creamer, R.; Ellwood, S.; Horne, J.; Hornung, M.; Kennedy, V.H.; Monson, F.; Raine, L.; Osborn, D.; Parekh, N.R.; Parrington, J.; Poskitt, J.M.; Potter, E.; Reeves, N.; Rowland, A.P.; Self, P.; Turner, S.; Watkins, J.W.; Wood, C.M.; Woods, C.; Wright, J. (2016). Soil metals data 1998 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/def15f47-6aba-43db-a833-5844628a658b

Black, H.I.J.; Chaplow, J.S.; Creamer, R.; Hornung, M.; Monson, F.; Poskitt, J.M.; Potter, E.; Self, P.; Watkins, J.W.; Wood, C.M. (2016). Soil invertebrate data 1998 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/f3e71ba6-bfd7-4841-9ce4-fd1f0d590d2d

Bunce, R.G.H. and Shaw, M.W., 1973. National survey of semi-natural woodlands. (ITE Merlewood report)

Bunce, Robert. 1978 Land classification for regional surveys. In: Barrow, G. C., (ed.) The assessment of ecological and recreational resources at the regional and national scales. An account of the meeting of the Recreation Ecology Research

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

Group, held at Battleby Centre, Redgorton, Perth, March 31st – April 2nd, 1978. Recreation Ecology Research Group, 11-14.

Bunce, R.G.H., Barr, C.J., Clarke, R.T., Howard, D.C. and Lane, A.M.J., 1996. ITE Merlewood land classification of Great Britain. *Journal of Biogeography*, *23*(5), pp.625-634.

Bunce, R.G.H., Barr, C.J., Clarke, R.T., Howard, D.C., Lane, A.M.J. (1990). ITE Land Classification of Great Britain 1990. NERC Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/ab320e08-faf5-48e1-9ec9-77a213d2907f

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

Bunce, R.G.H., Metzger, M.J., Jongman, R.H.G., Brandt, J., De Blust, G., Elena-Rossello, R., Groom, G.B., Halada, L., Hofer, G., Howard, D.C. and Kovář, P., 2008. A standardized procedure for surveillance and monitoring European habitats and provision of spatial data. Landscape ecology, 23, pp.11-25.

Bunce, R.G.H.; Hornung, M.; Hatton, A.; Stevens, P.A.; Cummins, R.; French, D. (2016). Soil physico-chemical properties 1978 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/85c71959-0f7c-4f04-b3a7-152673107a85

Callahan, B.J., McMurdie, P.J., Rosen, M.J., Han, A.W., Johnson, A.J.A. and Holmes, S.P. (2016). DADA2: High-resolution sample inference from Illumina amplicon data. Nature Methods, 13, 581–583

Caporaso, J.G., Lauber, C.L., Walters, W.A., Berg-Lyons, D., Lozupone, C.A., Turnbaugh, P.J., Fierer, N. and Knight, R. (2011). Global patterns of 16S rRNA diversity at a depth of millions of sequences per sample. Proceedings of the National Academy of Sciences, 108(Supplement 1), 4516–4522.

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. NERC/Centre for Ecology & Hydrology, 105pp. (CEH Project Number: C03259)

Carvalho, F., Montag, H., Bentley, L., Šarlej, R., Broyd, R. C., Blaydes, H., Cattin, M., Burke, M., Wallwork, A., Ramanayaka, S. 2025. Plant and soil responses to ground-mounted solar panels in temperate agricultural systems. *Environ. Res. Lett.* 20 024003. 10.1088/1748-9326/ada45b

Cnaan, A., Laird, N.M. and Slasor, P., 1997. Using the general linear mixed model to analyse unbalanced repeated measures and longitudinal data. *Statistics in medicine*, *16*(20), pp.2349-2380.

DAERA, 2026. The 4th Northern Ireland Countryside Survey. https://www.daera-ni.gov.uk/articles/4th-northern-ireland-countryside-survey#toc-1. Accessed 13/04/2026

De Rosa, D., Ballabio, C., Lugato, E., Fasiolo, M., Jones, A., & Panagos, P. (2024). Soil organic carbon stocks in European croplands and grasslands: How much have we lost in the past decade?Global Change Biology, 30, e16992. https://doi.org/10.1111/gcb.16992

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



DEFRA (2009). Cross Compliance Soil Protection Review 2010. Published by the Department for Environment, Food and Rural Affairs. 50pp.

Ebuele, V.O.; Tandy, S.; Brentegani, M.; Lebron, I.; Tye, A.; Keith, A.; Hermansen, C.; Wollesen de Jonge, L.; Zaresourmanabad, M.; Robinson, D.A. (2025). Topsoil visible and near-infrared (Vis-NIR) spectral data from the UKCEH Countryside Survey, Great Britain, 2018-2019. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/ea727f8d-6441-4d88-8ed7-1760bda0c3c3

Emmett, B.A., Anthony, S., Arnett, J., Bentley, L.F., Bell, C., Blaker, J., Botham, M., Bowgen, K.M., Brentegani, M., Campbell, H., Chetiu, N.F., Crossley, P., Deacon, A., Dhiedt, E., Doeser, A., Dos Santos Pereira, G., Ebuele, V., Feeney, C., Fitos, E., Garbutt, R.A., Hunt, M., Jarvis, S.G., Keenan, P., Kimberley, A., Lord, W., Macgregor, C.J., Maskell, L., Monkman, G., Mondain-Monval, T.O., Norton, L., O'Neil, A., Radbourne, A., Reinsch, S., Richardson Jones, V., Robinson, D.A., Robinson, I., Rowland, C.S., Salisbury, E., Scarlett, P., Siriwardena, G.M., Smart, S.M., Tandy, S., Thacker, S., Wallace, H., Waters, E., Whitworth, E., Williams, B., Williams, G., Williamson, J.L., Wood, C. (2025). Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP). ERAMMP Report-105: Wales National Trends and Glastir Evaluation. Report to Welsh Government (Contract C208/2021/2022) (UK Centre for Ecology & Hydrology Project 08435)
Emmett, B.E.1, Abdalla, M.18, Anthony, S.16, Astbury, S.1, August, T.1, Barrett, G.1, Beckman, B.1, Biggs, J.14, Botham, M.1, Bradley, D.2, Brown, M.1, Burden, A.1, Carter, H.1, Chadwick, D.3, Cigna, F.7, Collier, R.19, Cooper, D.1, Cooper, J.1, Cosby, B.J.1, Creer, S.3, Cross, P.3, Dadam, D.8, Edwards, F.1, Edwards, M.13, Evans, C.1, Ewald, N.14, Fitton, A1, Garbutt, A.1, Giampieri, C.1, Gooday, R.16, Grebby, S.7, Greene, S.1, Halfpenney, I.10, Hall, J.1, Harrison, S.17, Harrower, C.8, Henrys, P.1, Hobson, R.9, Hughes, P.19, Hughes, S.1, Illian, J.20, Isaac, N.1, Jackson, B.21, Jarvis, S.1, Jones, D.L.3, Jones, P.15, Keith, A.1, Kelly, M.6, Kneebone, N.2, Korenko, J.17, Lallias, D.3, Leaver, D.1, Lebron, I.1, Malcolm, H.1, Maskell, L.1, McDonald, J.3, Moxley, J.1, Norton, L.1, O'Hare, M.1, Oliver, T.1, Owen, A.1, Parkhill, K.A.3, Pereira, M.1, Peyton, J.1, Pogson, M.18, Powney, G.1, Pritchard, N.1, Pritchard, S.4, Prochorskaite, A.17, Prosser, M.11, Pywell, R.1, Rawlins, B.7, Reuland, O.21, Richards, M.18, Robinson, D.A.1, Rorke, S.1, Rowland, C.1, Roy, D.1, Scarlett, P.1, Scholefield, P.1, Scott, A1, Scott, L.12, Scott, R.1, Sharps, K.1, Siriwardena, G.8, Smart, S.1, Smith, G.17, Smith, P.18, Stopps, J.16, Swetnam, R.17, Taft, H.3, Taylor, R.3,8, Tebbs, E.1, Thomas, A1., Todd-Jones, C.20, Tordoff, G.9, Turner, G.7, Van Breda, J.5, Vincent, H.1, Wagner, M.1, Waters, E.1, Walker-Springett, K.3, Wallace, H.11, Watkins, J.1, Webb, G.1, White, J.17, Whitworth, E.16, Williams, B. 1 , Williams, P.14, Wood, C.1 and Wright, S.1 (2017) Glastir Monitoring & Evaluation Programme. Final Report to Welsh Government. Contract reference: C147/2010/11. NERC/Centre for Ecology & Hydrology (CEH Projects: NEC04780/NEC05371/NEC05782)

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

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.

Report from 2007. Technical Report No. 9/07 NERC/Centre for Ecology & Hydrology 192pp. (CEH Project Number: C03259).

Emmett, B., Frogbrook, Z., Chamberlain, P., Giffiths, R., Pickup, R., Poskitt, J., Reynolds, B., Rowe, E., Spurgeon, D., Rowland, P., & Wilson, J. (2008). Countryside Survey Technical Report No 03/07.

Golchin, A., Baldock, J.A., Oades, J.M., 2018. A model linking organic matter decomposition, chemistry, and aggregate dynamics. In: Lal, R., Kimble, J.M., Follett, R.F., Stewart, B.A. (Eds.), Soil Processes and the Carbon Cycle. CRC Press, Boca Raton, FL, pp. 245–266.

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.M.; Woods, C. (2016). Soil physico-chemical properties 2007 [Countryside Survey] . NERC Environmental Information Data Centre. https://doi.org/10.5285/79669141-cde5-49f0-b24d-f3c6a1a52db8

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.M.; Woods, C. (2016). Topsoil mineralisable nitrogen (mineral-N) data 2007 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/3bafb72b-9f2a-4cbc-a7b8-46e3731c6759

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.M.; Woods, C. (2016). Soil metals data 2007 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/826b0829-7ab5-4e22-822f-ee3a137896a9

Emmett, B.A.; Reynolds, B.; Chamberlain, P.M.; Rowe, E.; Spurgeon, D.; Brittain, S.A.; Frogbrook, Z.; Hughes, S.; Keith, A.M.; Lawlor, A.J.; Monson, F.; Poskitt, J.; Potter, E.; Robinson, D.A.; Scott, A.; Thompson, N.; Watts, R.; Wood, C.M.; Woods, C. (2016). Soil invertebrate data 2007 [Countryside Survey]. NERC Environmental Information Data Centre. https://doi.org/10.5285/fccd86b0-f5b6-4716-b4f7-f43ad82daeee

Farmer, J. G., Graham, M. C., Eades, L. J., Lilly, A., Bacon, J. R. 2016. Influences upon the lead isotopic composition of organic and mineral horizons in soil profiles from the National Soil Inventory of Scotland (2007–09), Science of The Total Environment, Volume 544, Pages 730-743, https://doi.org/10.1016/j.scitotenv.2015.11.127.

Feeney, C.J., Robinson, D.A., Keith, A.M., Vigier, A., Bentley, L., Smith, R.P., Garbutt, A., Maskell, L.C., Norton, L., Wood, C.M., Cosby, B.J. and Emmett, B.A., 2023. Development of soil health benchmarks for managed and semi-natural landscapes. *Science of the Total Environment*, *886*, p.163973.

Feeney, C.J., Robinson, D.A. and Emmett, B.A., 2025. Response to commentary by Hollis et al. on "The development of soil health benchmarks for managed and semi-natural landscapes". *Science of the Total Environment*, *984*, p.179711.

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Feeney, C.J., Bentley, L., De Rosa, D., Panagos, P., Emmett, B. A., Thomas, A., Robinson, D. A., 2024. Benchmarking soil organic carbon (SOC) concentration provides more robust soil health assessment than the SOC/clay ratio at European scale, Science of The Total Environment, Volume 951,175642, https://doi.org/10.1016/j.scitotenv.2024.175642.

Feeney, C.J., Cosby, B.J., Robinson, D.A. *et al.* Multiple soil map comparison highlights challenges for predicting topsoil organic carbon concentration at national scale. *Sci Rep* 12, 1379 (2022). https://doi.org/10.1038/s41598-022-05476-5

Forest Research, 2025. NFI Soil Condition & Health. [Dataset] Forestry Commission Open Data. https://data-forestry.opendata.arcgis.com/documents/600a707cac0a47c3acd146e565dbeacb/about?path=

George, P.B., Lallias, D., Creer, S., Seaton, F.M., Kenny, J.G., Eccles, R.M., Griffiths, R.I., Lebron, I., Emmett, B.A., Robinson, D.A. and Jones, D.L., 2019. Divergent national-scale trends of microbial and animal biodiversity revealed across diverse temperate soil ecosystems. Nature communications, 10(1), p.1107.

Golchin, A., Baldock, J.A., Oades, J.M., 2018. A model linking organic matter decomposition, chemistry, and aggregate dynamics. In: Lal, R., Kimble, J.M., Follett, R.F., Stewart, B.A. (Eds.), Soil Processes and the Carbon Cycle. CRC Press, Boca Raton, FL, pp. 245–266.

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: 1642-1654. https://doi.org/10.1111/j.1462-2920.2011.02480.x

Heikkinen, J., Ketoja, E., Nuutinen, V. and Regina, K., 2013. Declining trend of carbon in Finnish cropland soils in 1974–2009. *Global change biology*, *19*(5), pp.1456-1469.

Ihrmark, K., Bödeker, I.T.M., Cruz-Martinez, K., Friberg, H., Kubartova, A., Schenck, J., Strid, Y., Stenlid, J., Brandström-Durling, M., Clemmensen, K.E. and Lindahl, B.D. (2012). New primers to amplify the fungal ITS2 region – evaluation by 454-sequencing of artificial and natural communities. FEMS Microbiology Ecology, 82, 666–677.

Jones B, Goodall T, George PBL, Gweon HS, Puissant J, Read DS, Emmett BA, Robinson DA, Jones DL and Griffiths RI (2021) Beyond Taxonomic Identification: Integration of Ecological Responses to a Soil Bacterial 16S rRNA Gene Database. Front. Microbiol. 12:682886. doi: 10.3389/fmicb.2021.682886

Keith, A.M.; Dodd, B.A.; Turner, G.; Vane, C.H.; Wood, C.M. (2020). Soil mid-infrared spectroscopy data from arable and grassland in Countryside Survey, Great Britain 2007. NERC Environmental Information Data Centre. https://doi.org/10.5285/d66ca0a6-403d-4f5a-bef1-8ee177f1e1b3

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., Spurgeon, D., Wood, C.M. and Emmett, B.A. (2020). Monitoring Soil Natural Capital and Ecosystem Services by Using Large-Scale Survey Data. In Soil Ecosystems Services (eds M. Stromberger, N. Comerford and D. Lindbo). https://doi.org/10.2136/2015.soilecosystemsservices.2014.0070

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Kirk, G., P. Bellamy, B.A. Emmett and A. Scott. 2011. Comparison of topsoil carbon changes across England and Wales estimated in the Countryside Survey and the National Soil Inventory. Defra report SP1101. Available on request from Defra.

Lark, R.M., Rawlins, B.G., Robinson, D.A., Lebron, I. and Tye, A.M. (2014), Implications of short-range spatial variation of soil bulk density for adequate field-sampling protocols: methodology and results from two contrasting soils. Eur J Soil Sci, 65: 803-814. https://doi.org/10.1111/ejss.12178

Lark, R.M., Bellamy, P.H. & Kirk, G.J.D.(2006) Baseline values and change in the soil, and implications for monitoring. *European Journal of Soil Science*, 57, 916–921

Lark, R. M. (2012). Some considerations on aggregate sample supports for soil inventory and monitoring. European Journal of Soil Science, 63(1), 86-95. https://doi.org/10.1111/j.1365-2389.2011.01415.x

Lebron I, Cooper D M, Brentegani M A, Bentley L A, Dos Santos Pereira G, Keenen P, Cosby J B, Emmett B, Robinson D A. 2023 *Vadose Zone J.* e20300

Lebron, I.; Ebuele, V.O.; Brentegani, M.; Tandy, S.; van Soest, M.; Garbutt, A.; Bentley, L.; Williams, B.; Wood, C.M.; Emmett, B.A.; Robinson, D.A. (2025). Topsoil particle size distribution, electrical conductivity, calcite and total carbon from the Countryside Survey of Great Britain for 2018-2023, and aggregate information for 2019. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/6893097f-f504-4b77-96c8-8daa5da6a09d

Lilly, A., Bell, J.S., Hudson, G., Nolan, A.J. & Towers. W. (Compilers) (2010). National soil inventory of Scotland (NSIS_1); site location, sampling and profile description protocols. (1978-1988). Technical Bulletin. Macaulay Institute, Aberdeen. DOI:10.5281/zenodo.4650230

Medlin, L., Elwood, H.J., Stickel, S. and Sogin, M.L. (1988). The characterization of enzymatically amplified eukaryotic 16S-like rRNA-coding regions. Gene, 71, 491–499.

Metzger, M.J., Bunce, R.G.H., Jongman, R.H., Mücher, C.A. and Watkins, J.W., 2005. A climatic stratification of the environment of Europe. *Global ecology and biogeography*, *14*(6), pp.549-563.

Moeys, J., Shangguan, W., Petzold, R., Minasny, B., Rosca, B., Jelinski, N., Zelazny, W., Souza, R. M. S., Safanelli, J. L., & ten Caten, A. (2024). Soiltexture: Functions for soil texture plot, classification and transformation* (Version 1.5.3) [R package manual]. Comprehensive R Archive Network (CRAN). https://cran.r-project.org/web/packages/soiltexture/soiltexture.pdf

Natural Resources Wales, State of Natural Resources Report (SoNaRR 2025), December 2025, 807pp, NRW, Cardiff

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



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., 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, Volume 113, Pages 117-127, https://doi.org/10.1016/j.jenvman.2012.07.030.

Office for National Statistics (ONS), released 15 May 2024, ONS website, statistical bulletin, Woodland natural capital accounts, UK: 2024

Orgiazzi, A., Ballabio, C., Panagos, P., Jones, A. and Fernández-Ugalde, O. (2018), LUCAS Soil, the largest expandable soil dataset for Europe: a review. Eur J Soil Sci, 69: 140-153. https://doi.org/10.1111/ejss.12499

Panagos, P., Jones, A., Lugato, E. and Ballabio, C., 2025. A soil monitoring law for Europe. *Global Challenges*, *9*(3), p.2400336.

Poulton, Paul, Johnston, Johnny, Glendining, Margaret, White, Rodger, Gregory, Andy, Clark, Suzanne, Wilmer, Wendy S, Macdonald, Andy, Powlson, David (2024) The Broadbalk Wheat Experiment, Rothamsted, UK Crop yields and soil changes during the last 50 years. Advances in Agronomy, 184. pp. 173-298. ISSN 0065-2113

Pravia, A., Barreto, C., Ashwood, F. and Keith, A., 2025. Oribatid mite taxa and composition associated with temperate habitats in Great Britain. Applied Soil Ecology, 215, p.106471.

Prosser, M. & Wallace, H. (2008). Countryside Survey 2007: Quality Assurance exercise. Report to Centre of Ecology and Hydrology, Lancaster.

Raffeld, A.M., Bradford, M.A., Jackson, R.D. *et al.* The importance of accounting method and sampling depth to estimate changes in soil carbon stocks. *Carbon Balance Manage* 19, 2 (2024). https://doi.org/10.1186/s13021-024-00249-1

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., Black, H.I.J. and Emmett, B.A. (2013), Countryside Survey: National "Soil Change" 1978–2007 for Topsoils in Great Britain—Acidity, Carbon, and Total Nitrogen Status. Vadose Zone Journal, 12: 1-15 vzj2012.0114. https://doi.org/10.2136/vzj2012.0114

Reinsch, S., Lebron, I., Brentegani, M. *et al.* Co-located ecological data for exploring top- and subsoil carbon dynamics across grassland-woodland contrasts. *Sci Data* 11, 478 (2024). https://doi.org/10.1038/s41597-024-03333-w

Reinsch, S.; Bentley, L.; Brentegani, M.; Carter, H.; Dhiedt, E.; Ebuele, V.; Emmett, B.A.; Hunt, A.; Keenan, P.; Keith, A.; Lebron, I.; Lucas, J.R.; Monkman, G.; Pereira, M.G.; Richardson-Jones, V.; Rowe, R.; Salisbury, E.; Tandy, S.; Wood, C.M.; Ardeshir, D.; Biddle, A.; Boffey, C.; Ceallaigh, C.; Cope, S.; Fothergill, C.; Friend, R.; Handley, J.; Handley, T.; Higgins, A.; Horninge, L.; Moir, A.; O'Neil, A.; Savage, C.; Scott, H.; Shepherd, S.; Ward, T.; Jan Winder; Jon Winder; Robinson, D.A. (2025). Topsoil physico-chemical properties from the Environment and Rural Affairs Monitoring & Modelling Programme, Wales, 2021-2023. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/deabe608-fc6e-4d3a-812f-fb08ae515121

© Author(s) 2026. CC BY 4.0 License.

Reinsch, S.; Bentley, L.; Brentegani, M.; Chetiu, N.; Dhiedt, E.; Emmett, B.A.; Fitos, E.; Garbutt, R.A.; Guyatt, H.; Henrys, P.A.; Hunt, A.; Keenan, P.; Keith, A.M.; Lebron, I.; Mensah, E.; Pallett, D.W.; Pereira, M.G.; Risser, H.; Rowe, R.L.; Salisbury, E.; Scarlett, P.; Smart, S.M.; Tandy, S.; Wagner, M.; Wallace, H.; Wood, C.M.; Robinson, D.A. (2023). Topsoil physico-chemical properties from the UKCEH Countryside Survey, Great Britain, 2022. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/d53fdf1d-767a-4046-821a-ea645001ddd3

Reinsch, S., Lebron, I., deJonge, L. W., et al. 2025. "The Fraction of Carbon in Soil Organic Matter as a National-Scale Soil Process Indicator." Global Change Biology31, no. 11: e70572. https://doi.org/10.1111/gcb.70572.

Robinson, D.A., Williams, B., Smart, S., Wood, C., Garbutt, A., Fitos, E., Rowe, R., Emmett B. (2023). UKCEH Countryside Survey: Soil Handbook 2019-2023. Soil Cores. UKCEH Countryside Survey. Issue Number 2.3. https://nora.nerc.ac.uk/id/eprint/538891/1/N538891RE.pdf

Robinson, D.A., Thomas, A., Reinsch, S. *et al.* Analytical modelling of soil porosity and bulk density across the soil organic matter and land-use continuum. *Sci Rep* 12, 7085 (2022). https://doi.org/10.1038/s41598-022-11099-7

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. (2024). 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

Rovira, P., Sauras-Yera, T., Romanyà, J., Equivalent-mass versus fixed-depth as criteria for quantifying soil carbon sequestration: How relevant is the difference? CATENA, Volume 214, 106283, https://doi.org/10.1016/j.catena.2022.106283.

Seaton, F. M., Robinson, D. A., Monteith, D., Lebron, I., Bürkner, P., Tomlinson, S., Emmett, B. A., & Smart, S. M. (2023). Fifty years of reduction in sulphur deposition drives recovery in soil pH and plant communities. Journal of Ecology, 111, 464–478. https://doi.org/10.1111/1365-2745.14039

Schneider, F., Amelung, W. & Don, A. Origin of carbon in agricultural soil profiles deduced from depth gradients of C:N ratios, carbon fractions, $\delta^{13}C$ and $\delta^{15}N$ values. *Plant Soil* 460, 123–148 (2021). https://doi.org/10.1007/s11104-020-04769-w

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

Simfukwe P, Hill PW, Emmett BA, Jones DL (2021) Identification and predictability of soil quality indicators from conventional soil and vegetation classifications. PLOS ONE 16(10): e0248665. https://doi.org/10.1371/journal.pone.0248665

Six, J., Elliott, E.T., Paustian, K., Doran, J.W., 1998. Aggregation and soil organic matter accumulation in cultivated and native grassland soils. Soil Sci. Soc. Am. J. 62, 1367-1377.

Sohi, S.P., Mathieu, N., Arah, J.R.M., Powlson, D.S., Madari, B., Gaunt, J.L. 2001. A procedure for isolating soil organic matter fractions suitable for modelling. Soil Sci. Soc. Am. J., 65, 1121-1128.

Sohi, S.P., Mathieu, N., Powlson, D.S., Madari, B., Smittenberg, R.H., Gaunt, J.L. 2005. Investigating the chemical characteristics of soil organic matter fractions suitable for modelling. Soil Sci. Soc. Am. J., 69, 1248-1255.

© Author(s) 2026. CC BY 4.0 License.



Soil Survey of Scotland Staff, 1981. Soil maps of Scotland at a scale of 1: 250 000.

Soil Survey of Scotland, 1984. *Organization and methods of the 1: 250 000 soil survey of Scotland*. Macaulay Institute for Soil Research.

Smart, S.M.; Andrews, C.; Fitos, E.; Garbutt, R.A.; Gray, A.; Henrys, P.A.; Koblizek, E.; Pallett, D.W.; Robinson, D.A.; Rose, R.J.; Rowe, R.L.; Scarlett, P.; Towill, J.; Wagner, M.; Williams, B.; Wood, C.M. (2020). Vegetation plot data from the UKCEH Countryside Survey, Great Britain, 2019. NERC Environmental Information Data Centre. https://doi.org/10.5285/fd6ae272-aeb5-4573-8e8a-7ccfae64f506

Smart, S.M., Maskell, L.C., Norton, L.R., Wood, C.M., Bunce, R.G.H., Barr, C.J., Garbutt, R.A. (2021). UKCEH Countryside Survey: Vegetation plots field handbook 2019-2023. UKCEH Countryside Survey. Issue Number 1.5. https://nora.nerc.ac.uk/id/eprint/538889/1/N538889RE.pdf

Smart, S.M.; Andrews, C.; Brentegani, M.; Fitos, E.; Garbutt, R.A.; Gray, A.; Henrys, P.A.; Long, C.E.; Meek, B.; Mullally, S.; Ó Ceallaigh, C.; O'Rourke, C.; Pallett, D.W.; Peet, E.; Scarlett, P.; Wagner, M.; Wallace, H.; Williams, B.; Wood, C.M. (2022). Vegetation plot data from the UKCEH Countryside Survey, Great Britain, 2020 and 2021. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/48b52173-de8d-46c0-8e59-be3b819e234a

Smart, S.M.; Andrews, C.; Brown, K.; Cope, S.; Fitos, E.; Friend, R.; Garbutt, R.A.; Gray, A.; Hancock, G.; Higgins, A.; Moscrop, A.; O'Brien, L.; O'Ceallaigh, C.; O'Ceallaigh, T.; Pallett, D.W.; Scarlett, P.; Towill, J.; Wagner, M.; Wood, C.M. (2024). Vegetation plot data from the UKCEH Countryside Survey, Great Britain, 2022 and 2023. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/2859b031-ec69-48df-891f-58fbf6f942cb

Takahashi S., Tomita J., Nishioka K., Hisada T., Nishijima M. (2014). Development of a prokaryotic universal primer for simultaneous analysis of Bacteria and Archaea using next-generation sequencing. PLoS One9: e105592. 10.1371/journal.pone.0105592

Thomas, A., Bentley, L., Feeney, C., Lofts, S., Robb, C., Rowe, E. C., Thomson, A., Warren-Thomas, E., Emmett, B. 2023. Land degradation neutrality: Testing the indicator in a temperate agricultural landscape, Journal of Environmental Management, Volume 346, 118884, https://doi.org/10.1016/j.jenvman.2023.118884.

Thomas, A., Cosby, B. J., Henrys, P., Emmett, B., 2020 Patterns and trends of topsoil carbon in the UK: Complex interactions of land use change, climate and pollution, Science of The Total Environment, Volume 729, 138330, https://doi.org/10.1016/j.scitotenv.2020.138330.

Vigier, Audric ; Feeney, Christopher ; Robinson, David ; Keith, Aidan ; Radbourne, Alan ; Emmett, Bridget . UKCEH Countryside Survey Soil Health Webtool SOil funDamentals (SOD). 2023, https://connect-apps.ceh.ac.uk/soilhealth/ [Output (Electronic)]

https://doi.org/10.5194/essd-2026-459
Preprint. Discussion started: 9 November 2026
© Author(s) 2026. CC BY 4.0 License.



Weekers, P.H.H., Gast, R.J., Fuerst, P.A. and Byers, T.J. (1994). Sequence variations in small-subunit ribosomal RNAs of Hartmannella vermiformis and their phylogenetic implications. Molecular Biology and Evolution, 11, 684–690.

Wood, C.M., Metzger, M.J. and Bunce, R.G., 2025. Protecting the Bunce legacy: lessons learned from safeguarding long-term ecological survey datasets in Great Britain. Environmental Management, pp.1-14.

Wood, C. M., Smart, S. M., Bunce, R. G. H., Norton, L. R., Maskell, L. C., Howard, D. C., Scott, W. A., and Henrys, P. A.: Long-term vegetation monitoring in Great Britain – the Countryside Survey 1978–2007 and beyond, Earth Syst. Sci. Data, 9, 445–459, https://doi.org/10.5194/essd-9-445-2017, 2017.

Wood, C. M., Alison, J., Botham, M. S., Burden, A., Edwards, F., Garbutt, R. A., George, P. B. L., Henrys, P. A., Hobson, R., Jarvis, S., Keenan, P., Keith, A. M., Lebron, I., Maskell, L. C., Norton, L. R., Robinson, D. A., Seaton, F. M., Scarlett, P., Siriwardena, G. M., Skates, J., Smart, S. M., Williams, B., and Emmett, B. A.: Integrated ecological monitoring in Wales: the Glastir Monitoring and Evaluation Programme field survey, Earth Syst. Sci. Data, 13, 4155–4173, https://doi.org/10.5194/essd-13-4155-2021, 2021.