JNCC Report 793

25 Year Environment Plan Outcome Indicator E7: Healthy soils – proposed method for a soil health indicator for England

Annex 1
Natural Capital and Ecosystem Assessment Programme data collection and analysis: progress to date

Doo, B., Hathaway-Jenkins, L., Harrison B. and Schmidt, S.

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JNCC's report series serves as a record of the work undertaken or commissioned by JNCC. The series also helps us to share, and promote the use of, our work and to develop future collaborations.

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1. Data collection and analysis

1.1. Natural Capital and Ecosystem Assessment Programme

National soil monitoring is currently being undertaken within the Natural Capital and Ecosystem Assessment (NCEA) programme, as part of the England Ecosystem Survey. The NCEA is supported by substantial new government investment, delivering a baseline assessment of location, extent and condition for these vital natural capital assets at national and regional levels within England, alongside improving our long-term monitoring capabilities. The current phase will be completed in 2025/26 and will be the third year of the five-year survey needed for a robust soil health baseline. We are bidding through the next phase of the Spending Review for the capital investment needed to complete the data collection for the baseline by 2028.

1.2. England Ecosystem Survey

The England Ecosystem Survey (EES) – a strategic sample field survey managed by Natural England – is a significant data source for the NCEA programme, measuring quality of natural capital assets. The EES is collecting field data on vegetation, landscape, soil, ecosystem quality, habitats, ecological communities, and some species. Field assessment and soil sampling procedures are conducted as part of the EES. Data are being collected on the soil type and on the physical, chemical, and biological soil properties across England's terrestrial ecosystems. This excludes woodlands, which are covered by the National Forest Inventory Plus (NFI+), another survey component of the NCEA programme, managed by Forest Research. Soils data from the NFI+ will be incorporated into the finalised version of the E7 Soil Health indicator.

The EES monitoring plots are clustered within squares measuring 1 × 1 km (monads). Monads are aligned to the Ordnance Survey British National grid and selected via a stratified random sampling approach combined with use of inclusion probability weightings. Within each monad, there are up to six predetermined 1 ha squares (Landscape and Vegetation Squares) surrounding a 2 × 2 m 'Vegetation Plot'. The Landscape and Vegetation Square is used to capture and report on habitat heterogeneity and complexity.

Each Landscape and Vegetation Square is overlaid at the centre by a 13 by 13 grid of 16 × 16 m squares, extending beyond the Landscape and Vegetation Square. These 16 × 16 m squares are options for a 'Soil Plot', of which there are 169 options per Square to choose from. One Soil Plot option is chosen per Landscape and Vegetation Square, equating to up to six Soil Plots per monad. The default position for the Soil Plot is at the centre of the Landscape and Vegetation Square. When conditions are unsuitable, an alternative option is chosen from the grid of Soil Plot options, following a standardised process.

Each Soil Plot is overlaid with 8 by 8 evenly distributed 1 m squares, with the centre four squares reserved undisturbed for the 2 × 2 m Vegetation Plot, in which plant species composition and broad habitat is recorded. The 60 remaining 1 m squares surrounding the Vegetation Plot are options for 'Soil Sampling Points'. Four Soil Sampling Points are chosen per Soil Plot; these are randomly selected, although the default position for the four sampling points is consistent across all Soil Plots. Adjustments to the default Soil Sampling Point locations are permitted if deemed unsuitable for soil sampling purposes, following a consistent approach. Soil data were collected during the soil sampling and assessments

survey via a field software app and via collected samples which were sent for further laboratory analysis as part of the EES.

Below is an extract of data collected during the first sampling year of the EES. This is an incomplete and pre-experimental dataset to be used as indicative of approach only. The data have been only partially cleaned and have only received provisional assurance from the NCEA programme to be used for illustrative purposes.

2.   Illustrative example of data

A reduced soil dataset for 180 monads (up to 432 Soil Plots) was collated, including the number of earthworms, visual evaluation of soil structure (VESS), pH and estimated soil organic matter (SOM) content. Metadata, such as soil temperature, sampling location, and date of soil sampling was collected for each sampling point.

To assess the number of earthworms, a soil block measuring 20 × 20 × 20 cm at the south-east corner of each soil sampling point was dug out. After breaking up the soil along natural planes and fissures, earthworms were collected from within the soil block. The number of earthworms found at each soil sampling point was recorded and the total number of earthworms found per soil plot reported.

For the VESS, a block adjacent to the earthworm pit on the northern side was dug out, measuring 30 cm deep and the width of a spade. The soil structure of this block was visually assessed using the method developed by Ball *et al*. (2007). The VESS scores ranged from 1 to 5, with increments of 0.5. The VESS score for the four soil sampling points within each soil plot was averaged, which provided a weighted average VESS score.

Soil samples for pH and organic matter analysis were collected within each soil sampling point using a split corer with inner diameters of either 4.8 cm (standard) or 4.5 cm (core catcher). Sampling depth was standardized at 15 cm, and soil from the four soil sampling points was collected as a composite sample.

The pH was measured on a soil volume of 10 ml of air-dried, sieved soil (less than 2 mm) in a 25 ml deionized water solution.

For Soil Organic Matter (SOM) analysis, composite samples from the different soil plots were air-dried at temperatures less than 30°C and passed through roller sieves smaller than 2 mm. For the analysis of total carbon (TC), the sieved soil was ground to particles less than 0.5 mm. The TC content was determined through Dumas combustion at 1,200°C coupled with Infrared Red (IR) spectrometry on 100–150 mg of ground soil. Total inorganic carbon (TIC) content was assessed by acidifying the sample with orthophosphoric acid and sparging it at 150°C to liberate inorganic carbonates as carbon dioxide (CO_2). The resulting gas mixture, containing CO_2, was passed through the IR detector along with an oxygen carrier gas. Total organic carbon (TOC) was calculated by subtracting TIC from TC. In this instance, due to data unavailability, SOM was estimated from TOC content using the standard conversion factor of 1.72 which assumes that SOM contains 58% carbon (van Bemmelen 1890).

The reduced soil dataset was cleaned with errors in location (e.g. incorrect monad identified) and in each variable (e.g. SOM, pH, Earthworms and VESS) identified and where possible corrected. A summary of the dataset was created showing minimum, median, mean, maximum, standard deviation, and number of samples for each variable within each broad habitat type that was covered during year one of sampling.

Broad habitat type was recorded for both the 2 x 2 m vegetation plot and fixed 1 ha square surrounding the vegetation plot during the EES vegetation and landscape survey in 2023. The dominant habitat type in the plot was recorded if straddling two habitats or in a mosaic. Broad habitat type was recorded using the UK Biodiversity Action Plan (UK BAP) broad habitat classification.

The broad habitat data were joined with the soil data by spatial intersection on ArcGIS Pro. If a soil plot was co-located with a vegetation plot, the broad habitat data recorded from the 2 x 2 m vegetation stand were used. If a soil plot was not co-located with a vegetation plot,

the stand broad habitat data were used. If a soil plot was located outside of the 1 ha square and not co-located with a vegetation plot or where more than 1 broad habitat was recorded within the 1 ha square, the soil data were not used.

The summary statistics were calculated in R (using the summary tools package), using the cleaned reduced soil dataset. The data ranges of this dataset are presented in Table 1.

To assure scientific quality, the summary statistics and method statement behind the data ranges were put through the NCEA Defra Science Assurance process. This involved an internal review conducted by the Defra NCEA team, followed by a working group review with representatives from Natural England and Environment Agency. Relevant components of the data's value chain were assessed, including data testing, quality assurance and independent data calibration. Following review, 'Provisional Assurance' was given, noting that the data are pre-experimental, and to be used as indicative of approach only.

Table 1. Data ranges (minimum (min) and maximum (max)) of pH, estimated soil organic matter content (SOM), visual evaluation of soil structure (VESS) and earthworm count data collected during the first year of the England Ecosystem Survey. Please note that due to missing data, the minimum and maximum ranges for SOM and pH are provided for 178 monads, the earthworm count is given for 180 monads, and the VESS score is reported for 159 monads.

Broad habitat	Earthworm count (earthworm number)		VESS Score		pH		SOM (%, estimated)	
	min	max	min	max	min	max	min	max
Acid grassland	0	45	1	4.5	4.2	5.9	2.8	45.6
Arable and horticultural	0	155	1	5	5.5	8.5	1.4	29.2
Bog	0	0	1	5	3.5	4.6	22.2	81.2
Bracken	0	15	1	2.5	4.1	6.1	8.6	12.7
Calcareous grassland	19	31	1	3.5	5.8	8.4	5.7	13.8
Dense scrub	28	133	1.5	2	7.6	8.4	5.2	8.3
Dwarf shrub heath	0	7	1	4	3.7	5.2	6.9	82.4
Fen, marsh and swamp	0	0	1	1	6.2	6.2	22.2	22.2
Improved grassland	0	161	1	4	4.5	8	1.2	70.2
Mosaic	0	51	2	4.5	3.8	6.1	9.6	64.7
Neutral grassland	0	116	1	4	4.8	8.1	1.9	24.1
Tall herbs	46	46	1.5	1.5	7.1	7.1	5.7	5.7

Note that this is an incomplete and pre-experimental dataset to be used as indicative of approach only. The data to produce a reduced dataset have been only partially cleaned and have only received provisional assurance from the NCEA programme to be used for illustrative purposes. In this instance, due to data unavailability SOM (%) was estimated from Total Organic Carbon content using the standard conversion factor of 1.72 (van Bemmelen 1890).

References

Ball, B.C., Batey, T. & Munkholm, L.J. 2007. Field assessment of soil structural quality – a development of the Peerlkamp test. *Soil Use and Management*, **23**(4), 329–337. https://doi.org/10.1111/j.1475-2743.2007.00102.x.

Van Bemmelen, J.M. 1890. Über die Bestimmung des Wassers, des Humus, des Schwefels, der in den colloïdalen Silikaten gebundenen Kieselsäure, des Mangans u.s.w. im Ackerboden. *Die Landwirtschaftlichen Versuchs-Stationen*, **37**, 279–290.

Weblinks

Table 2. Full URLs for weblinks used in the text.

Weblink text	Full URL
NCEA	https://defraenvironment.blog.gov.uk/2024/03/28/mapping-our-natural-assets-the-natural-capital-and-ecosystem-assessment-programme/
EES	https://naturalengland.blog.gov.uk/2024/04/03/england-ecosystem-survey-introducing-englands-largest-ever-field-survey/