

## **Considerations in the use of Countryside Survey soil data**

### **Sampling design**

Soils were sampled in Countryside Survey (CS) in 1978, 1998, 2007 and 2019. In both 1978 and 1998 the same 256 squares were sampled, whilst in 2007 soils were collected from all 591 CS squares – but not all measurements were made on all samples. Power analyses were carried out to determine the number of samples required to detect significant change (see Emmett et al. 2008). A pilot survey was carried out in 2018, and 2019 was the start of a rolling survey with the aim to measure ~100 squares each year for five years before repeating.

### **Sample location**

Soils are sampled from the CS X-plots, and there are 5 of these plots randomly spaced in a CS square. The X-plots within a square are NOT replicates, as they may be in very different land uses, on different soil types etc. Over the years, X-plots are sometimes relocated due to the destruction of a plot (e.g. it's turned into a car park) or permission to access the land is denied, or the lack of certainty in relocating the original plot location. However, each location has a unique repeat identifier, e.g. 2RPT1, which refers to square 2, repeat plot 1, where repeat plot 1 is a known location in the square. Samples with the same unique identifier should be considered to come from the same location, although the exact locations from which soils were sampled will be ca. 2 - 3 m apart as we move around the 4 corners of a permanently marked 2 m x 2 m plot at each sampling location. See Emmett et al. (2008) for further information.

### **Sampling**

Soils are only collected from the top 15 cm (8 cm for the invertebrate sample) of the soil profile, in 1998, 2007 and the 2019 rolling survey this was done using a soil core hammered in to the soil and then pulled out. In 1978, a soil pit was dug and soil collected from the top 15 cm of the profile in the side of the pit. In some soils, it is not possible to collect a full 15-cm long core due to stones, or shallow soils. Core photographs and detailed measurements of core dimensions were made by lab staff in 2007 on the 2 of the 4 cores sampled (black cores and N mineralization cores). This method was adopted for the rolling CS survey.

### **Measurements**

The only laboratory measurements made in 1978 were pH and loss-on-ignition (LOI). In CS1990, some soil mapping was carried out. Multiple cores were taken from each X-plot in 1998, 2007 and the CS rolling survey 2018/2019-2023, and different cores have different measurements made on them. No chemical analyses are made by soil horizons – samples are homogenised before pH and LOI measurements. Bulk density was measured in 2007, and 2018/19-2023 but not by using the ISO bulk density method (which would have required a whole core simply for this measurement). A report on the implication of this and a full description of methods is available (Emmett et al. 2008).

### **Statistical analysis**

Statistical analyses of CS soils data should take note of the statistical issues outlined above. Soils results do not always take account of the land class structure. If the land classes are not taken into account, then results are the stock and change of the population, whilst if the land classes are taken into account, the results are weighted by the land classes and results become national estimates of stock and change. Likewise, bootstrapping is not always used in analyses of soils data. However, the structure of CS should be taken into account and at the least a mixed model should be used, with square as a random factor, to take into account the fact that multiple X-plots (up to 5) are contained within each CS square. Finally, in contrast to some monitoring programmes only one core is taken per location but it should be noted that design based approaches such as CS, where spatial structure is

not generally of interest, a dispersed set of observations is the most efficient approach and overall precision and coverage is increased by widespread placing of samples if regional estimates are required. We advise all users of CS soils data to consult with UKCEH prior to analysis and interpretation and to check on publications already released which exploit the data which are listed on the CS website.

## **References**

Emmett, BA, ZL Frogbrook, PM Chamberlain, R Griffiths, R Pickup, B Reynolds, E Rowe, P Rowland, D Spurgeon, J Wilson, CM Wood. *Countryside Survey Soils 2007: Method development, power analyses and protocols*. Centre for Ecology and Hydrology Project No. C03042/ DEFRA Contact No. CR0334.