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Designing a national soil erosion monitoring network for England and Wales

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Although soil erosion is recognised as a significant threat to sustainable land use and may be a priority for action in any forthcoming EU Soil Framework Directive, those responsible for setting national policy with respect to erosion are constrained by a lack of robust, representative, data at large spatial scales. This reflects the process-orientated nature of much soil erosion research. Recognising this limitation, The UK Department for Environment, Food and Rural Affairs (Defra) established a project to pilot a cost-effective framework for monitoring of soil erosion in England and Wales (E&W). The pilot will compare different soil erosion monitoring methods at a site scale and provide statistical information for the final design of the full national monitoring network that will:

- provide unbiased estimates of the spatial mean of soil erosion rate across E&W (tonnes ha^{-1} yr^{-1}) for each of three land-use classes -
  (a) arable and horticultural
  (b) grassland
  (c) upland and semi-natural habitats
- quantify the uncertainty of these estimates with confidence intervals.

Probability (design-based) sampling provides most efficient unbiased estimates of spatial means. In this study, a 16 hectare area (a square of 400 x 400 m) positioned at the centre of a 1-km grid cell, selected at random from mapped land use across E&W, provided the sampling support for measurement of erosion rates, with at least 94% of the support area corresponding to the target land use classes.

Very small or zero erosion rates likely to be encountered at many sites reduce the sampling efficiency and make it difficult to compare different methods of soil erosion monitoring. Therefore, to increase the proportion of samples with larger erosion rates without biasing our estimates, we increased the inclusion probability density in areas where the erosion rate is likely to be large by using stratified random sampling. First, each sampling domain (land use class in E&W) was divided into strata; e.g. two sub-domains within which, respectively, small or no erosion rates, and moderate or larger erosion rates are expected. Each stratum was then sampled independently and at random. The sample density need not be equal in the two strata, but is known and is accounted for in the estimation of the mean and its standard error.

To divide the domains into strata we used information on slope angle, previous interpretation of erosion susceptibility of the soil associations that correspond to the soil map of E&W at 1:250 000 (Soil Survey of England and Wales, 1983), and visual interpretation of evidence of erosion from aerial photography. While each domain could be stratified on the basis of the first two criteria, air photo interpretation across the whole country was not feasible. For this reason we used a two-phase random sampling for stratification (TPRS) design (de Gruijter et al., 2006). First, we formed an initial random sample of 1-km grid cells from the target domain. Second, each cell was then allocated to a stratum on the basis of the three criteria. A subset of the selected cells from each stratum were then selected for field survey at random, with a specified sampling density for each stratum so as to increase the proportion of cells where moderate or larger erosion rates were expected. Once measurements of erosion have been made,

an estimate of the spatial mean of the erosion rate over the target domain, its standard error and associated uncertainty can be calculated by an expression which accounts for the estimated proportions of the two strata within the initial random sample.

de Gruijter, J.J., Brus, D.J., Biekens, M.F.P. & Knotters, M. 2006. Sampling for Natural Resource Monitoring. Springer, Berlin.

Soil Survey of England and Wales. 1983 National Soil Map NATMAP Vector 1:250,000. National Soil Research Institute, Cranfield University.