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Chapter 10 Recommendations for a sampling scheme to monitor the soil of England and Wales

10.1 Introduction

A soil monitoring scheme is required for England and Wales to record the sustainability of the soil resource, and as part of an integrated policy for environmental protection. This was recommended strongly by the Royal Commission for Environmental Pollution (RCEP, 1996). The concern of the Ministry of Agriculture, Food and Fisheries is with sustainable use of the soil resource in particular, environmental protection, and with food safety in relation to the uptake of heavy metals from the soil. There is a need to assess the long-term effects of the use of the soil by the agricultural industry.

Any proposed monitoring scheme has to anticipate many eventualities to meet future needs. Some of the needs are as yet unknown and cannot be predicted, others that are known might alter as the social and physical environments change. Both temporal and spatial changes in the soil need to be considered and these have different requirements in terms of monitoring. One of the reasons for analysing the National Soil Inventory (NSI) is to provide suggestions for a spatial soil monitoring scheme for England and Wales. The results show that these data provide a valuable base line from which to design a scheme to monitor the soil spatially. Distinctive regional patterns are evident in the soil maps produced, and these can aid the design of the scheme. The analyses that provide the basis for our recommendations are variography, kriging of the subsets, factorial kriging and disjunctive kriging. We can also make suggestions about monitoring over time, but these are not based on the results of analyses.

The variogram models fitted to most variables, quantitative, qualitative and the leading principal components, have a nested form. For the quantitative variables, the average short-range component is 24 km and the average long-range one is 89 km. Based on a ‘rule of thumb’ a reasonable sampling interval to take is half the variogram range. In this instance this would be half of the short-range component, i.e., about 10 km. In addition, once the variogram is known sampling can be optimized in relation to a tolerance level provided by the user (see below).

Variograms of variables for several subsets of the data based on rainfall, altitude and soil classes show a similar form to those described above. If the variograms for the high rainfall area, also associated with pastoral land-use, had had a somewhat

different form from those of the drier areas associated with arable farming, then there might have been some justification for treating these two strata differently for monitoring. The variograms for the larger soil classes also still show a nested structure with similar ranges of spatial dependence to those for the full data. In the event there is no justification for subdividing the country for designing a soil monitoring scheme based on rainfall, altitude or soil type.

10.2 Sampling for spatial monitoring

The results in Chapter 9 for sampling suggest that a square 10-km sampling grid provides a considerable saving in sampling, compared with the original 5-km sampling of the NSI, without losing a substantial amount of the detail in the variation. Such a grid would require a minimum of 1418 sites, just 25% of the original NSI data. This sampling intensity is supported by the results of kriging the subsets, the MSEs, factorial kriging, moving averages and the optimal sampling analysis. Much of the short-range variation is lost, however, with a 10-km grid. If there are areas based on the short-range results or, more particularly, those from disjunctive kriging where more information is required, then additional sampling with a shorter interval should be considered at selected grid nodes. If we consider the maps of the probabilities of exceeding statutory thresholds of pollutants or of being deficient in soil nutrients, areas with probabilities less than 0.3 and more than 0.7 could be disregarded from the point of view of monitoring. This is because where the probabilities are large (high zone) there is a considerable chance that the concentration of the element will exceed the threshold. Equally for probabilities between 0 and 0.3 (low zone) there is a small chance only of the concentration exceeding the threshold. Areas with probabilities of 0.3 to 0.7 are marginal in relation to the threshold and it is here that additional sampling might be focused. If change has occurred in the concentrations of the elements in the marginal areas, they could become low or high probability zones. Such change could be a response to changing climate conditions or anthropogenic activities.

Since many variograms have similar forms it suggests that there are strong and permanent factors controlling the variation, such as geology. This means that even though future data will be on a coarser grid, the variogram from the present analysis could be used for kriging or geostatistical simulation. New variograms could be

computed, however, using the current NSI data and any new information from future monitoring.

A reasonable time interval for spatial monitoring might be on a ten-year cycle. The Representative Soil Sampling Scheme (RSSS) (Skinner & Todd, 1998) examines 180 fields every year and 800 every five years, or 1600 every 10 years. This does not provide continuous information at places over time, therefore it is difficult to compare maps of properties from one sampling to another. At this stage we suggest that permanent sites should be used for monitoring, and sampling on a 10-km grid every 10 years would represent a similar investment to the current one for the RSSS. The information from such monitoring sites would provide a basis for the long-term assessment of the health of the soil resource. Countryside 2000 also offers a spatial sampling scheme, but it is not based on a grid, and the number of 'sites' within England and Wales - *c.* 275 - from which soil samples are taken is, on the basis of the work reported here, too small to represent the spatial structure of the data adequately.

10.3 Sampling for temporal monitoring

A detailed temporal record of the soil is likely to be too costly at many sites. There is already a well-established monitoring network comprising the eleven sites of the Environmental Change Network (ECN). This could form the basis for temporal monitoring in England and Wales, depending on the assessment of the current five and 20-year samplings.

For temporal monitoring, local spatial effects must be excluded so that any changes with time can be identified. The present approach to soil sampling on the 1-ha sites is to use a bulked sample from 25 cores taken over the area. This effectively excludes the local spatial effects. In the event that the ECN sites were not used, we would recommend a minimum of 10 sites and ideally 20 sites for the above hierarchical temporal monitoring of the soil. It is possible that urban and agricultural sites might need to be included in such a monitoring scheme, in which case a minimum of 20 sites would be needed and, ideally, 30.

10.4 Conclusions

The different sampling strategies proposed for temporal and spatial monitoring are the basis for a hierarchical scheme for monitoring the soil of England and Wales. The work presented in this report has indicated strongly that a square 10-km sampling grid

is sufficient to show the spatial pattern of many topsoil chemical and related properties in England and Wales. This reduced grid, compared with the much denser NSI 5-km grid, represents a considerable saving of resources, in terms of a soil monitoring network. Nevertheless, it retains much of nationally relevant spatial information. We suggest, also, that this 10-km grid could serve a number of purposes currently covered by other monitoring schemes, without serious loss of spatial information. An element of flexibility could be introduced into the spatial sampling scheme, if desired, by using additional sites to those at the grid nodes for examining specific areas. Further, the rainfall strata, which reflect the two major types of land-use could be used as a basis for managing the sampling in practical terms. For example, a major soil survey could be carried out in one stratum at one period of time and the other stratum could be surveyed five years later. This means that the budget for monitoring could be distributed more evenly over time, as could the man-power for undertaking the survey and analytical work. It might be prudent, however, to examine this conclusion in more detail, before any commitment is made to favour one scheme above another.