The development and use of soil quality indicators for assessing the role of soil in environmental interactions

Summary SC030265/SS

Healthy soils are vital to a sustainable environment. They store carbon, produce food and timber, filter water and support wildlife and landscapes, However, there are increasing signs that UK soils have been neglected and may be undergoing irreversible damage. Further, a 2004 report by the Environment Agency on the state of soils in England and Wales found was that there was not enough quality information on these soils, without which it is not possible to develop policies to protect and improve soil quality. A new report by the Environment Agency attempts to address these problems, by establishing indicators of soil quality which could be used to monitor the state of soils on a nationwide scale.

Selecting indicators for soil quality monitoring is a potentially onerous task. Indicators need to be meaningful and easy to interpret for a range of soils. Furthermore, an indicator needs to respond directly and promptly to perturbation; any change it reflects should be understandable in terms of the desired condition for that soil. Other criteria include potential costs and ease of measuring the indicator.

This project builds on the findings of a previous Environment Agency-led project, *Identification and development of a set of national indicators for soil quality*. The 2002 project concluded that soil quality indicators (SQIs) should be based on soil function, with the most important functions being those of environmental interaction, food and fibre production, support for ecological habitat and biodiversity, the provision of raw materials and protection of cultural heritage. From a choice of 67, the report identified nine key functional indicators.

In order to further these findings, a consortium was set up with members from the Environment Agency, Countryside Commission for Wales (CCW), Department for Environment, Food and Rural Affairs (Defra), Forestry Commission, Scottish Executive, English Heritage, National Assembly of Wales, Scottish National Heritage and the Scottish Environmental Protection Agency. Through the consortium, the function-based approach was adopted and the members were charged with leading on specific soil functions which fell within their remit. Defra was chosen to lead on food and fibre production and English Heritage on protection of cultural heritage. The Environment Agency was charged with establishing SQIs for the function of environmental interaction. Examples of important soil interactions with the environment include the filtering of groundwater and carbon gas exchanges with the atmosphere, and impacts on surface water quality.

This report assessed potential indicators identified in the first project, and others not yet identified, in terms of their relevance to, sensitivity to and discrimination of soil quality. The report's objectives were to:

- Establish procedures for using the indicators depending on different requirements for information, for example for policy questions at a national scale or more localised issues of concern.
- Test the selected indicators, using medium to long-term scenarios such as climate change, to establish a minimum dataset (MDS) - the minimum number of indicators needed for policy decisions and national-scale assessments.
- Select trigger values or workable ranges for those indicators chosen for the MDS, above or below which change would be critical in terms of the soil's fitness for a specific use. Using these triggers, soils sampled at different time intervals could be compared and the changes interpreted.
- Gain a broad consensus across the UK soil science community of the suitability of the indicators for soil monitoring in the UK.

The Environment Agency used a consensus-based approach to achieve these objectives, seeking consortium and expert peer-review and feedback throughout the project. As part of this 'challenge process', Environment Agency staff drafted reports on each of the eleven indicators selected for this project. The reports explored the relevance, interpretation,

measurability and cost of the chosen indicators, and were reviewed by a group of expert peer-reviewers and consortium members, whose suggestions and recommended changes were then incorporated into revised drafts (presented in this report). The revised texts formed the basis for discussion at a two-day technical workshop with a broader group of experts, including academics, consultants, practitioners and policy makers from the UK soil science community. Summaries of the peer-review process and group findings from the workshop are given in appendices to this report.

This outcome of this project was the establishment of a minimum dataset of indicators - that is, soil organic carbon (SOC), total N (nitrogen), Olsen extractable P (phosphorus), available and total copper (Cu), nickel (Ni) and zinc (Zn), bulk density and pH.

The project also established a tiered, risk-based procedure for users to select indicators for soil sampling and monitoring based on identified levels of risk, in line with the UK government's current guidance for environmental risk assessment. At the first level of this decision-based framework, the MDS provides generic information on the state of soils, identifying dominant trends and areas at risk of deterioration in function. Increasing levels of risk, identified via the exceedance of trigger values or knowledge of a risk specific to land use and soil types (for example, cropping on a specific soil type may routinely cause soil loss and affect surface water quality), guides the user through further levels of decision-making. The MDS also includes collection of contextual information on site characteristics, land use history, soil classification and profile description.

Biological indicators of soil quality that could be incorporated into an MDS are not yet well developed and are at present treated largely as research tools. A review of these tools is currently being carried out under a Defra-funded project, *SP0529: SQID: Soil quality indicators - developing biological indicators*.

Trigger values or workable ranges for each of the MDS indicators were initially established using baselines or ranges of values for soil types linked to habitats/land uses, from which significant changes could be identified. Some SQIs trigger values are relatively straightforward to define, such as pH. However, the process was more difficult for semi-natural, low-nutrient ecosystems, because of a paucity of data and the relative insensitivity of some, such as Olsen P. Nevertheless, the technical workshop generated trigger value tables for some indicators, whereas for others, such as SOC, alternative approaches were suggested including the use of reference sites or 'no increase values' under specific site conditions.