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Visual soil evaluation — a key tool for better management of risks to soils

A new review of the potential uses of visual soil evaluation (VSE) shows how this tool can be used to indicate risks of erosion, compaction, greenhouse gas emission or storage and surface-water run-off. Assessing soils in this way is not only useful for agriculture, but has implications for the wider environment, due to the vital role that soil plays in the provision of ecosystem services, for example as a habitat for biodiversity and as a carbon sink.

Soil structure — the spatial arrangement of soil particles and pores (empty spaces) — provides physical habitat for soil organisms, and controls many functions associated with ecosystem services, for example by storing water and allowing plants to grow. Soil's ability to withstand and recover from stresses (stability and resilience) is also an important aspect of soil structure, as it determines the risk of compaction, which inhibits plant growth and other life. Soil degradation in the EU could cost up to €38 billion per year, according to the EU's Thematic Strategy for Soil Protection[1]. Measures to protect soils, and the functions they perform, are part of the Seventh Environment Action Programme[2].

VSE offers a method of assessing the quality of soil structure, which is not static (such as soil texture), but changes due to external influences, including weather, penetration of plant roots and human activity, such as tillage or driving of vehicles. VSE is mainly used by agricultural advisors and farmers to assess and inform soil management techniques. Requiring no special equipment, it is a simple and cheap tool.

Despite the use of manuals and scales in the evaluation process, one limitation of VSE is considered to be subjective interpretation, as compared to assessing the detailed information offered by computed tomography (CT) imaging, for example. Nevertheless, the researchers behind this paper argue that VSE can provide a crucial tool for monitoring soils, and provide an in-depth review of opportunities and future directions for the technique, based on a 2014 workshop attended by scientists from the ISTRO (International Soil Tillage Research Organization).

Many different VSE methods have been proposed. These techniques generally assess the depth of natural and anthropogenic soil layers, the spatial arrangement and size distribution of soil particles, the strength of the soil, its visible porosity, and, sometimes, colour and earthworm population, amongst other variables. Some methods incorporate a soil-quality index, such as the commonly used 'Visual Soil Assessment' method[3]. The different features assessed offer information on how well different plants will grow in the soil, its potential as biological habitat and how nutrients will be cycled in the soil. For example, features such as cloddy structure and surface ponding give clues as to how water drains from the soil. Some VSE studies have shown significant correlations between soil structure and crop yield[4], while others provide useful tools to assess soil recovery after heavy compaction[5].

Continued on next page.

1. Communication (COM/2006/0231) on a Thematic Strategy for Soil Protection

2. Decision (1386/2013/EU) on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'

3. Shepherd, T.G. (2009). Visual Soil Assessment. *Field Guide for Pastoral Grazing and Cropping on Flat to Rolling Country* (2nd edition), vol. 1. Horizons Research Council, Palmerston.

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Visual soil evaluation — a key tool for better management of risks to soils *(continued)*

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A useful future application of VSE would be to expand soil analysis by including remote sensing. Where areas of degraded soil have been identified with remote sensing techniques — by drone, for example — VSE could be used for further, detailed investigation. This would be particularly useful for precision farming[6], the researchers suggest, where agricultural inputs (e.g. fertilisers, pesticides or irrigation) are related to soil variables. Furthermore, integrating VSE with mobile device apps could make soil- quality scoring easy to compile and transmit to experts online.

Analysis can also indicate the ability of a soil to store carbon, release greenhouse gases and lose nutrients — and, therefore, has relevance for climate change science. For instance, VSE has been used to estimate risk of soil emissions of nitrous oxide from compacted pastures where high levels of fertiliser have been applied. Assessment can also indicate the risk of surface-water run-off and nutrient loss.

Data from VSE before and after tillage could be used to build models of the effect of the process on soil structure, the researchers suggest. In particular, better understanding is needed of compaction from the use of large farm machinery, which is a major threat to soils, as it can limit plant growth and crop productivity. VSE, in combination with granular matter physics, could help scientists understand the mechanics of tilled soil layers, say the researchers, which can then inform farm practices and policy aimed at protecting soils. Combining the low-tech VSE tool with other technologies could, therefore, assist in better management of agricultural soils and improve soil protection in Europe.

4. e.g. Munkholm, L.J., *et al*. (2013). Long-term rotation and tillage effects on soil structure and crop yield. *Soil & Tillage Research*, 127: 85–91.

5. Boizard, H., *et al*. (2013). Using a morphological approach to evaluate the effect of traffic and weather conditions on the structure of a loamy soil in reduced tillage. *Soil and Tillage Research*, 127: 34–44.

6. This is an agricultural management approach using information technology, satellite positioning (GNSS) data, remote sensing and proximal data gathering. These technologies aim to optimise returns on inputs whilst reducing environmental impacts.