# Putting soil health on the agenda

With the SQUARE project, TEAGASC, UCD, UL and IT Sligo are identifying indicators of soil health in Ireland.

## A precious resource

Soil is a precious resource that supports essential functions, including: food, feed and fibre production; nutrient cycling; carbon sequestration and climate regulation; water purification; and, as a habitat for biodiversity. The sustainable management of agricultural soils is critical for achieving the growth targets set out in Food Wise 2025, and for protecting soil resources (post 2020 EU-CAP). Grass-based animal production systems rely heavily on soil quality to deliver profitable and sustainable production. But what is soil quality or soil health?

Soil quality has been described as the soil's ability to provide ecosystem services through its capacity to perform the functions mentioned above under changing management and climatic conditions (Toth *et al.*, 2007). Recently this term has been replaced by 'soil health', which really focuses more on the soil biological community as a key driver of soil functionality. In light of this, monitoring of soil health is required to better manage and protect our agricultural soils and their viability for future generations.

## SQUARE

The Soil Quality Assessment and Research (SQUARE) project, funded by the Department of Agriculture, Food and the Marine (DAFM) from 2014 to 2018, was a collaboration between Teagasc, University College Dublin, the University of Limerick, and IT Sligo. Within SQUARE, an initial assessment of soil quality for 180 grassland farms in Ireland was completed.

The sites were geographically distributed across the five major agro-climatic regions of Ireland and classified into two soil drainage classes according to the Irish Soil Information System. SQUARE identified a selection of suitable indicators for assessing soil quality and health.

A key challenge for SQUARE was to identify soil health indicators that could sufficiently account for differences in: (i) intrinsic soil characteristics; (ii) spatial/climatic conditions; and, (iii) grassland management type and intensity. In addition to soil survey and pedalogical description, each farmer completed a detailed questionnaire in order to collect soil and grassland management information.

## Selecting suitable soil health indicators

Not all soil attributes are suitable indicators of soil health. However, certain soil properties play a major role in maintaining soil health, making them suitable indicators. A final matrix of key indicators of soil functionality was compiled for Irish grassland soils, including their ability to inform the delivery/supply of at least two out of five soil functions. Three classes of indicators (physical, chemical, and biological) were identified to provide holistic assessment of soil health (**Table 1**) (Bünemann *et al.*, 2018).

## What soil quality indicators are important for grassland soils?

Of the physical indicators identified, structure was considered a key factor that supports all soil functions. The decline in soil structural quality, which leads to soil degradation and compaction, is often the consequence of more intensive management practices. The chemical indicators provide much information in relation to nutrient cycling, primary production and carbon sequestration functions in soils. In particular, soil pH and soil organic matter were identified as key factors, which regulate nutrient availability in soil, and were considered highly relevant in the delivery of all the different soil functions, including carbon sequestration and macro/micronutrient cycling. The biological indicators provide the greatest information on the delivery/supply of all soil functions. This indicates that soil biodiversity and the soil microbiome is at the centre of soil functioning. However, some biological indicators were more difficult to measure and were impractical for soil health assessments.

## Are Irish grassland soils healthy?

Overall, the health status of Irish grassland soils is relatively good; however, we identified potential weaknesses under certain soils by weather or management situations where soil health may be negatively impacted. Our assessment of physical, chemical and biological indicators of soil health across grassland soils identified differences in the delivery of soil functions according to soil type, climatic region and grassland management system (i.e., grazing vs silage). While all soils have the capacity to deliver all functions, some soils were better at delivering particular functions compared to others. We found that well-drained soils were more resilient in terms of soil compaction and had high capacity to support the primary production function once balanced nutrition was supplied. However, these soils presented higher risk in terms of water purification and

**Table 1: Soil health key indicators selection. Indicator categorisation matrix and evaluation of their explanatory power for each soil function.**

| Key indicators | 1. Type | | 2. Suitability of indicator across different scales | | | 3. Feasibility of indicator measurement | | | 4. Relevance to delivery of soil functions* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Static | Dynamic | Soil pedon/ biota | Field | Landscape | Logistic | Extrapolation potential | Sensitivity | PP | WP | CS | BIO | NC |
| **Physical indicators** | | | | | | | | | | | | | |
| Soil texture | √ | | √ | | | | √ | √ | High | Low | High | Low | Low |
| Soil structure | | √ | √ | √ | √ | √ | √ | √ | High | High | High | High | High |
| Bulk density | | √ | √ | √ | | | √ | √ | High | High | Low | Low | Low |
| Hydraulic conductivity | | √ | | √ | √ | √ | √ | √ | High | High | Low | Low | Low |
| **Chemical indicators** | | | | | | | | | | | | | |
| pH | | √ | √ | √ | | √ | √ | √ | High | High | High | High | High |
| Macro/micronutrients | | √ | √ | √ | | √ | √ | √ | High | Low | High | Low | High |
| Soil organic matter | | √ | √ | √ | | √ | √ | √ | High | Low | High | High | High |
| Soil carbon fractions | | √ | √ | √ | | | √ | √ | High | Low | High | High | High |
| **Biological indicators** | | | | | | | | | | | | | |
| Earthworm abundance | | √ | √ | | | | | √ | Low | Low | High | High | High |
| Microbial biomass | | √ | √ | √ | | √ | √ | √ | High | High | High | High | High |
| Rooting type, depth and abundance | | √ | √ | √ | | √ | √ | √ | High | High | High | High | High |
| Botanical composition | | √ | | √ | √ | √ | √ | √ | High | High | High | High | High |
| Bacterial and fungal communities | √ | | √ | | | | | √ | Low | Low | High | High | High |
| Enzyme activity | | √ | √ | | | | √ | √ | Low | Low | High | High | High |

**Soil functions: PP = primary productivity; WP = water purification; CS = carbon sequestration; BIO = biodiversity; NC = nutrient cycling.*

climate regulation. In contrast, poorly drained soils were more prone to structural compaction and less resilient for production, especially with high trafficking intensity. On the other hand, these soils have high capacity to sequester carbon, to provide a habitat for an active microbiome under low to moderate management intensity.

## What next?

Thus far the results of the SQUARE project have led to the production of on-farm tools for a first quick assessment of soil health (Bondi *et al.*, 2018; Emmet-Booth *et al.*, 2018). These tools can now be used by farmers and practitioners to check the health status of their land. In addition, we need a long-term soil quality monitoring network to detect changes in soil health over time, and further research to find practical management solutions for its protection. This knowledge can be integrated with knowledge transfer services to provide advice to farmers and farm advisors. We have made a start but we have a long way to go!

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## References

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