Evaluating Soil Health Indicators: A Meta-Analysis

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Introduction

There is increasing interest from the agricultural community in understanding and quantifying the integrative concept of soil health.

Soil health management practices such as reduced tillage, no tillage, cover crops, and diverse rotations have the potential to enhance soil quality, water quality, and farm business goals when the practices are adapted to a farm's local conditions, including soils, climate, and cropping system.

The term **soil health indicator** refers to field- or lab-based methods used to evaluate the soil with respect to different soil functions or ecosystem services (Arsad & Martin, 2002). Dozens of different indicators have been proposed to monitor soil health, and there are several national efforts underway in the public and private sectors to evaluate the suitability of different indicators for quantifying soil health.

Quantifying and constraining sources of variability is an important step toward accounting for regional differences in observed soil health indicator values and creating realistic guidelines and interpretations for soil health management.

Fig. 1: A participant at a soil health field day hosted by UMN Extension examines soil structure.
Photo credit: UMN Extension

Objectives

Pool and analyze a global dataset of soil health indicator measurements extracted from peer-reviewed literature.

- Quantify the effect of different management practices on soil health indicators
- Identify how moderators such as mean annual temperature, mean annual precipitation, sampling time, and soil texture contribute to variability in select soil health indicators
- Identify research gaps where more data is needed to fully characterize the impact of management on soil health indicators

Figure 2 from L to R: Soybeans with high percentage of residue protecting soil surface; Mark Lefebvre of Stearns SWCD and UMN student Rowan Doyle sample soil in Stearns County; No-till soybeans planted into rye cover crop

Scope

Studies must meet the following criteria to be included in the review and meta-analysis.

Study Type

Conducted on farm, field, or plot scale

Management

Soil health practices: no till, reduced till, cover crops

Comparison

Conventional tillage and/or rotations

Indicators

Selected indicators from literature, NRCS, existing frameworks

Selected Indicators

Organic Matter Cycling & C Sequestration:
Soil Organic Matter, Soil Organic Carbon

Soil Structure & Infiltration:
Aggregate stability, penetration resistance, slaking, bulk density, saturated hydraulic conductivity, infiltration, available water holding capacity

Enzyme Activity:
B-glucosidase, N-acetyl-D-glucosaminidase, Arylsulfatase Phosphatase

Short-Term Carbon Mineralization:
Respiration

Soil Carbon Food Source:
Permanganate oxidizable C, soluble carbohydrates, particulate organic matter, water extractable organic C, substrate-induced respiration

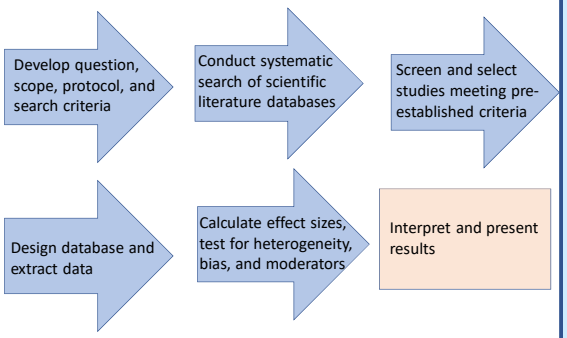
Soil organisms:
Microbial biomass, Berlese funnel extractions, earthworms, phospholipid fatty acid profiles, nematodes, springtails

Bioavailable Nitrogen:
Potentially mineralizable N, nitrate, ACE protein, cold water-soluble organic N, Solvita labile amino N test, IL soil nitrogen test

Table 1: Soil health indicators selected for review. Indicator categories adapted from Stott, 2019.

Methods

Researchers work in partnership with experts from the University of Minnesota Libraries' Systematic Review Service to follow best practices for evidence synthesis.



Expected Outcomes

The database and analysis generated during this process will advance scientific and practical conversations about soil health:

- Quantify the sensitivity of a broad range of soil health indicators to management changes
- Quantify how soil health indicator values vary by region and with climate and soil factors
- Determine which indicators have sufficient evidence to support meaningful interpretations and guidelines

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