What is Soil Quality?

Soil Quality -- Managing soil for today and tomorrow

SOIL QUALITY is how well soil does what we want it to do. More specifically, soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.

People have different ideas of what a quality soil is. For example:

- for people active in production agriculture, it may mean highly productive land, sustaining or enhancing productivity, maximizing profits, or maintaining the soil resource for future generations;
- for consumers, it may mean plentiful, healthful, and inexpensive food for present and future generations;
- for naturalists, it may mean soil in harmony with the landscape and its surroundings;
- for the environmentalist, it may mean soil functioning at its potential in an ecosystem with respect to maintenance or enhancement of biodiversity, water quality, nutrient cycling, and biomass production.

WHAT DOES SOIL DO?

Healthy soil gives us clean air and water, bountiful crops and forests, productive rangeland, diverse wildlife, and beautiful landscapes. Soil does all this by performing five essential functions:

- Regulating water. Soil helps control where rain, snowmelt, and irrigation water goes. Water and dissolved solutes flow over the land or into and through the soil.
- Sustaining plant and animal life. The diversity and productivity of living things depends on soil.
- Filtering potential pollutants. The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.
- Cycling nutrients. Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled through soil.
- Supporting structures. Buildings need stable soil for support, and archeological treasures associated with human habitation are protected in soils.

SOIL HAS BOTH INHERENT AND DYNAMIC QUALITY.

Inherent soil quality is a soil's natural ability to function. For example, sandy soil drains faster than clayey soil. Deep soil has more room for roots than soils with bedrock near the surface. These characteristics do not change easily.

Dynamic soil quality is how soil changes depending on how it is managed. Management choices affect the amount of soil organic matter, soil structure, soil depth, water and nutrient holding capacity. One goal of soil quality research is to learn how to manage soil in a way that improves soil function. Soils respond differently to management depending on the inherent properties of the soil and the surrounding landscape.

For more information about inherent soil characteristics, see the NRCS Soils site.

SOIL QUALITY IS LINKED TO SUSTAINABILITY.

Understanding soil quality means assessing and managing soil so that it functions optimally now and is not degraded for future use. By monitoring changes in soil quality, a land manager can determine if a set of practices are sustainable.

ASSESSING SOIL QUALITY

Soil quality is an assessment of how well soil performs all of its functions. It cannot be determined by measuring only crop yield, water quality, or any other single outcome. The quality of a soil is an assessment of how it performs all of its functions now and how those functions are being preserved for future use.

Soil quality cannot be measured directly, so we evaluate indicators. Indicators are measurable properties of soil or plants that provide clues about how well the soil can function. Indicators can be physical, chemical, and biological characteristics. Useful indicators :

are easy to measure measure changes in soil functions encompass chemical, biological, and physical properties are accessible to many users and applicable to field conditions are sensitive to variations in climate and management.

Indicators can be assessed by qualitative or quantitative techniques. After measurements are collected, they can be evaluated by looking for patterns and comparing results to measurements taken at a different time or field.

For more information, see the "Guidelines for Soil Quality Assessment"

Here are some examples of indicators of soil quality:

Indicator	Relationship to Soil Health
Soil organic matter (SOM)	Soil fertility, structure, stability, nutrient retention; soil erosion.
PHYSICAL: Soil structure, Depth of soil, Infiltration and bulk density; Water holding capacity	Retention and transport of water and nutrients; habitat for microbes; estimate of crop productivity potential; compaction, plow pan, water movement; porosity; workability.
CHEMICAL: ph; Electrical conductivity; extractable N-P-K	Biological and chemical activity thresholds;Plant and microbial activity thresholds; Plant available nutrients and potential for N and P loss.
BIOLOGICAL: Microbial biomass C and N; Potentially mineralizable N; Soil respiration.	Microbial catalytic potential and repository for C and N; Soil productivity and N supplying potential ;Microbial activity measure

SOIL QUALITY IS NOT AN END IN ITSELF

The ultimate purpose of researching and assessing soil quality is not to achieve high aggregate stability, biological activity, or some other soil property. The purpose is to protect and improve long-term agricultural productivity, water quality, and habitats of all organisms including people. We use soil characteristics as indicators of soil quality, but in the end, soil quality must be identified by how it performs its functions.

MANAGING FOR SOIL QUALITY

Each combination of soil type and land use calls for a different set of practices to enhance soil quality. Yet, several principles apply in most situations.

1. Add organic matter. Regular additions of organic matter are linked to many aspects of soil quality. Organic matter may come from crop residues at the surface, roots of cover crops, animal manure, green manure, compost, and other sources. Organic matter, and the organisms that eat it, can improve water holding capacity, nutrient availability, and can help protect against erosion.
2. Avoid excessive tillage. Tillage has positive effects, but it also triggers excessive organic matter degradation, disrupts soil structure, and can cause compaction. For more information about conservation tillage, visit the Conservation Tillage Information Center.
3. Carefully manage fertilizer and pesticide use. In this century, pesticides and chemical fertilizers have revolutionized U.S. agriculture. In addition to their desired effects, they can harm non-target organisms and pollute water and air if they are mismanaged. Manure and other organic matter also can become pollutants when misapplied or over-applied. On the positive side, fertilizer can increase plant growth and the amount of organic matter returned to the soil.
4. Increase ground cover. Bare soil is susceptible to wind and water erosion, and to drying and crusting. Ground cover protects soil, provides habitats for larger soil organisms, such as insects and earthworms, and can improve water availability. Cover crops, perennials, and surface residue increase the amount of time that the soil surface is covered each year.
5. Increase plant diversity. Diversity is beneficial for several reasons. Each crop contributes a unique root structure and type of residue to the soil. A diversity of soil organisms can help control pest populations, and a diversity of cultural practices can reduce weed and disease pressures. Diversity across the landscape and over time can be increased by using buffer strips, small fields, contour strip cropping, crop rotations, and by varying tillage practices. Changing vegetation across the landscape or over time increases plant diversity, and the types of insects, microorganisms, and wildlife that live on your farm.

RESEARCH POTENTIAL

Most soil quality research is motivated by one of two goals: 1) improving land management on farms and watersheds. 2) monitoring soil at a national or regional scale. The first goal involves site-specific assessment and decision-making, so the link between researchers and farmers is important to the success of the research.

Most research attempts to identify the links among management practices, observable soil characteristics (i.e. soil quality indicators), soil processes (e.g. nutrient cycling), and the performance of soil functions (e.g. productivity and environmental quality). A single study may examine only one or two of these links.

Some important directions for future research include:

- Measuring the spatial and temporal variability of soil characteristics, and using patterns of variability as an indicator of soil quality.
- Further define the characteristics of a healthy soil biological community, and approaches to managing soil biology.
- Describing and managing changes during the transition time when farmers switch from one set of practices to another.
- Improving nutrient cycling by managing soil biology.
- Identifying low-cost remote techniques for monitoring soil quality regionally.

OTHER INTRODUCTIONS TO SOIL QUALITY ON THE INTERNET

Soil Quality Information Sheets prepared by the National Soil Survey Center.

The USDA-SARE soil quality tip sheet #1 lists a number of soil quality publications.

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