# Soil Health

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### What is meant by soil health?

Soil health describes a soil's capacity to function as a living system that enhances plant productivity, maintains or restores environmental quality, and supports a diverse community of soil organisms.

Key soil properties involved in maintaining and improving soil health include nutrient cycling, the soil microbiome, soil water holding capacity, and soil organic matter (SOM).

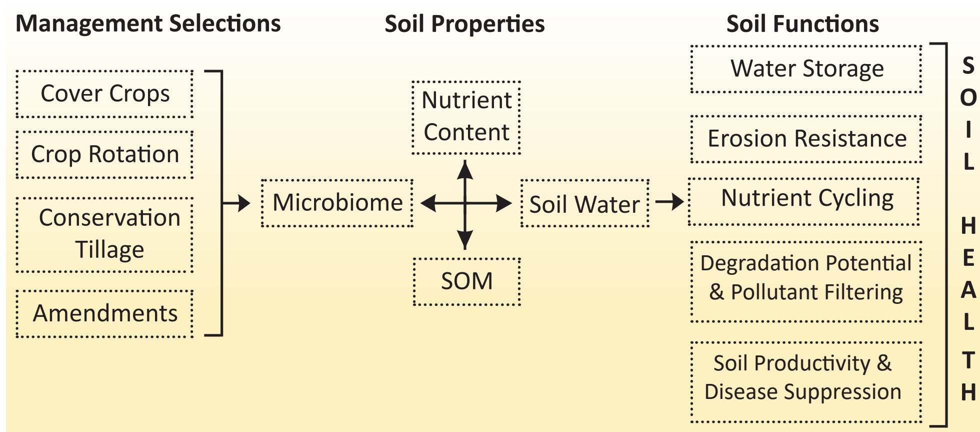


*Figure 1.* Management selections impact soil properties, which in turn impact soil functions and overall soil health (Cano et al, 2017).

### Why is soil health important to Ogallala region agriculture?

A healthy soil can improve crop yields, nutrient cycling, water infiltration, and resistance to erosion, all of which are vital to long-term agricultural sustainability.

**Careful selection of crops and crop rotations, tillage, and other management practices can improve both farm profitability and soil health for dryland, limited irrigation, and fully irrigated production systems for future generations.**

In the Ogallala region, precipitation events are limited yet often intense. The region's dryland, limited irrigation, and fully irrigated farming systems can all benefit from improved soil health, which may:

- increase water infiltration and, with increased surface residues, reduce soil moisture loss to evaporation, and
- improve nutrient cycling and soil aggregate formation.


*Figure 2.* Transitions to dryland production require careful management to maintain soil organic carbon and overall soil health (Cano et al, 2018).

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**What is the soil microbiome?**

Soil teems with life. A teaspoon of soil can contain as many as one billion cells belonging to thousands of individual bacterial species, one million fungal species, and thousands to millions of algae and protozoa species. All of these microbial groups — called the “soil microbiome” — complement each other’s contributions to healthy soil function. The soil microbiome regulates 80 – 90% of important soil processes including decomposition, nutrient cycling, soil and water detoxification, and disease suppression.

In the lab, researchers evaluate the biological components of soil health by:

- measuring different components of soil organic matter (SOM),
- measuring carbon in soil microbial biomass to estimate soil microbial abundance,
- looking at fatty acid profiles to estimate relative proportions of soil fungi and bacteria, and
- measuring activity of enzymes involved in nutrient cycling.

In addition, researchers assess the physical components of soil health by measuring soil aggregation (how soil particles are bound together), which affects water infiltration and storage.

Soil fungi play an important role in binding soil particles together to help create and maintain soil aggregates or soil structure. Arbuscular mycorrhizal

**How is soil organic matter (SOM) important to soil health?**

Soil organic matter (SOM) is chemically diverse and made up of plant, animal, and other materials in various states of decomposition. SOM is a critical component of soil health that contributes to soil nutrient availability and soil water storage and helps provide the environment that sustains the soil microbiome.

Changes in SOM are identified by analyzing its different components. Factors influencing changes in SOM levels include current SOM levels, the amount and quality of organic residues, soil management practices, and environmental conditions. The metabolism of micro-organisms also affects how SOM changes.

*Amando Cano (USDA-ARS, Texas Tech University), left, and Verónica Acosta-Martínez (USDA-ARS), right, sample soils in irrigated cotton near Lubbock, TX, to compare fields transitioning to dryland sorghum or grasses.*
*Left photo: Diane Vargas  Right photo: Jon Cotton*

**Soil organic matter (SOM) in the Ogallala region**

Low levels of precipitation combined with high evaporative demand and frequent high soil temperatures, especially in the Southern High Plains, lead to lower SOM levels compared to typical levels for soils in the U.S. Midwest.

Rainfed agricultural production typically leads to less plant biomass compared to irrigated production, also resulting in lower SOM levels. In low SOM situations, the soil microbial community shifts to one that can function with limited carbon inputs. In this scenario, soil microbial community diversity may decrease, further influencing SOM accumulation.

In limited irrigation and dryland systems, agricultural conservation practices that keep the soil covered and fed with plant residues are expected to improve SOM and the soil microbiome’s adaptation to climate variability, which may include prolonged drought, and to increase water use efficiency and crop yield (Cano et al, 2017).

*USDA-ARS soil microbiology laboratory in Lubbock, TX*
*Supervised by Verónica Acosta-Martínez*

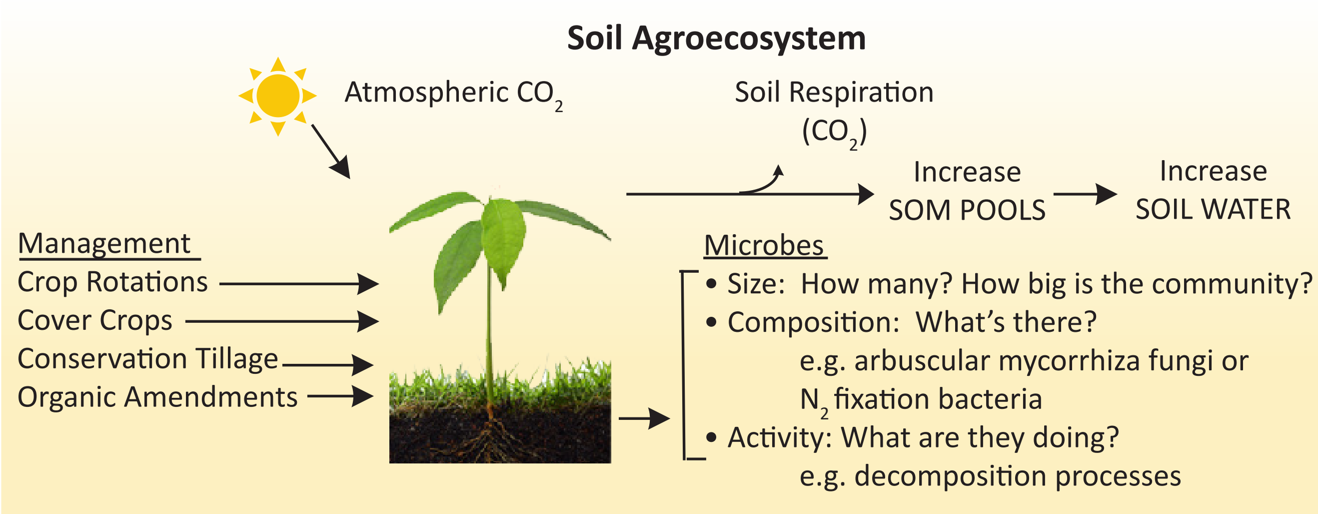


*Figure 3.* Decomposition of carbon (C) inputs from plant, animal, and other materials builds soil organic matter (SOM) and releases carbon dioxide ($CO_2$). In agroecosystems, soil organic matter is the result of a dynamic equilibrium of C inputs and C outputs from decomposition, leaching, and soil erosion (Cano et al, 2017).

**How does land use affect soil health?**

A study conducted near Clovis, NM (Thapa, Ghimire, Mikha, Omololu, & Marsalis, 2018) confirmed several soil health fundamentals for the semi-arid Southern High Plains already established for other less arid regions:

- Conversion to grassland restores soil organic carbon lost due to cultivation.
- Livestock integration in cropping system improves soil organic matter storage.
- Minimizing soil disturbance improves soil structure.

**Can cover crops be used in the Ogallala region to improve soil health?**

The majority of studies in the Central Great Plains and the Northern Great Plains suggests that cover cropping improves sustainability of cropping systems through their positive effects on soil organic carbon accumulation, nutrient cycling, soil erosion control, weed suppression, and soil health improvement.

Cover cropping could help improve soil health in limited irrigation systems or on land transitioning from irrigated to dryland production in the Southern and Central Great Plains. In limited irrigation conditions of eastern New Mexico, oat and its mixture with Brassicas or legumes as cover crops are effective in improving soil health (Ghimire, Ghimire, Mesbah, Sainju, & Idowu, 2019).

*Rajan Ghimire, left, (New Mexico State University) in one of his mixed cover crop research plots. Cover crop residues feed earthworms, right, which play an important role in improving soil aeration, water infiltration, and plant nutrient availability. Left photo: Amy Kremen Right photo: Rajan Ghimire*

However, integrating cover crops into croppng systems of the Southern Great Plains faces challenges because of low quantity of soil water availability. More cover crop research on the economics and tradeoffs between water use and agroecosystem benefits is required to successfully integrate cover crops into dryland cropping systems in the Southern Great Plains (Ghimire et al, 2018).

## Conclusion

In the Ogallala region, as producers in some areas shift away from irrigated to dryland production, over time a new balance in soil organic matter dynamics will be reached. Depending on the shift in crop rotations, this transition may result in increased or decreased crop residue inputs into the soil, and thus, different impacts on soil microbial communities and soil health. Typically, it can take several years to realize the benefits of shifts towards soil health-oriented management.

With proper selection of crop rotation, tillage, and other relevant management practices, it is possible to both improve farm profitability and maintain a healthy soil for limited irrigation or dryland production systems for future generations.

The best management practices for soil health will depend on each region's climate and soil conditions. Nonetheless, maintaining or improving soil health during a transition to dryland production will play an important role for agricultural sustainability and resiliency in the Ogallala region.

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