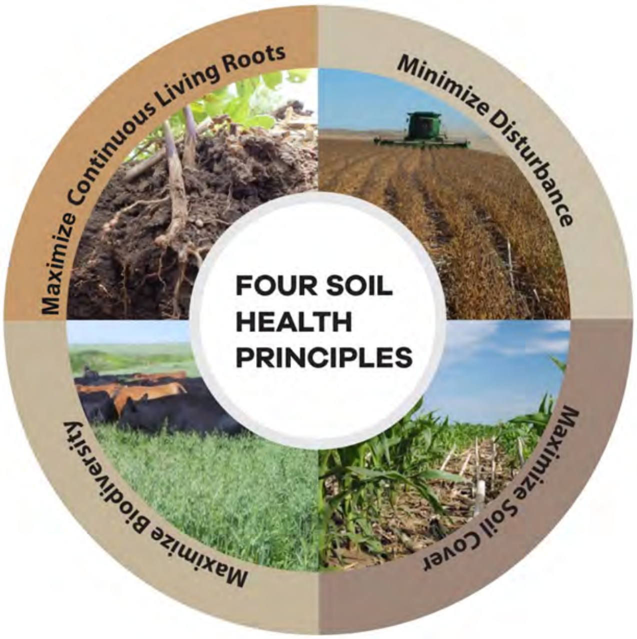
PRINCIPLES FOR HIGH FUNCTIONING SOILS

SOIL HEALTH DEFINED

Soil health is **the continued capacity of a soil to function as a vital, living ecosystem that sustains plants, animals, and humans**. Only living things can have "health," so viewing soil as a living, breathing ecosystem reflects a shift in the way we view and manage our nation's soils. Soil isn't an inert growing medium, but rather is the home of billions of bacteria, fungi, and other organisms that together create an intricate symbiotic ecosystem. This ecosystem can be managed to support plants and animals, by cycling nutrients, absorbing, draining and retaining rainwater and snowmelt for use during dry periods, filtering and buffering water to remove potential pollutants, and providing habitat for the soil biological population to flourish and diversify to keep the ecosystem functioning well.



KEY SOIL HEALTH MANAGEMENT PRINCIPLES

These principles are represented in the circular diagram to the right to emphasize their relationship as a continuum where each complements the others and also depends on the others.

1. Minimize disturbance
2. Maximize soil cover
3. Maximize biodiversity
4. Maximize presence of living roots

PROTECTING THE SOIL HABITAT

The first two principles, shown on the right side of the diagram above focus on protection of the soil habitat: minimize disturbance and maximize soil cover. Practices that use these principles maintain or increase stable soil aggregates and soil organic matter (SOM), and protect the surface of the soil that is most susceptible to the degrading forces of wind and water. Maximizing soil cover also buffers against temperature fluctuations that stress plants and soil organisms, reduces evaporation rates, and increases the amount of water entering the soil profile from precipitation and irrigation.

SOM is highest at the soil surface and is critical for stabilizing soil aggregates.

Maintaining SOM helps support additional soil functions including water infiltration, drainage and storage, nutrient-holding capacity and release, and habitat for soil biota.

FEEDING THE SOIL ORGANISMS INHABITING SOIL

The second two principles, shown on the left side of the circular diagram, focus on feeding soil organisms. Maximizing the diversity of food (energy and carbon inputs) and aboveground biodiversity increases the diversity of soil animals and microorganisms. Diversity not only refers to food sources, but also aboveground diversification of plants and animals, and microbial diversification underground. Diversification stimulates a host of additional benefits including breaking disease cycles, providing habitat for pollinators, and stimulating plant growth.

Maximizing the presence of living roots in the soil can be accomplished through eliminating fallow, diverse crop rotation, inclusion of cover crops, and/or through dedicated grasslands (native or pasture). Mixing up which plants are grown during the year or over the course of multiple years may help to break disease/pest cycles.

When these two principles are properly applied as part of a soil health management system, soils can maintain or even increase SOM content as well as enhance nutrient cycling.

Worm being born within the pore space of a well-aggregated soil.

HEALTHY, FUNCTIONING SOILS ARE ABLE TO:

- Cycle nutrients effectively
- Store carbon and nutrients in soil organic matter
- Provide good aeration to promote root growth
- Improve farm and ranch resiliency and profitability
- Improve yield stability
- Reduce runoff and erosion
- Improve water storage and plant available water while protecting water quality
- Be resilient to drought, heavy rainfall events, and temperature extremes
- Reduce disease and pest problems

Soil Health Management Systems Principles can be generally used in all production systems to achieve this. However, the specific practices chosen to implement the principles must be adapted to each production system, climate, ecosystem, and soil to effectively build and maintain healthy, functioning soil.

SOIL DISTURBANCES

Physical disturbances such as tillage or compaction from heavy machinery; Chemical disturbances such as fertilizer and pesticide applications, especially over application or misuse. Biological disturbances, such as over-grazing animals that can lead to compaction and reduction in perennial root systems, introduction of invasive species and/or use of monocultures can cause biological imbalances which all can affect soil functions.

SOIL COVER

consists of two main forms: 1) living plant canopy such as a growing crop, cover crop, or grassland; and 2) mulch, either as dead plant material (e.g. crop residues, prunings from trees and shrubs, thatch in grasslands) or as an amendment (e.g. compost, bark chips).

BIODIVERSITY

is the variation of life forms within a given ecosystem or field. The different life forms include all of the plants, animals and microorganisms, and their secretions. For soil health management systems, biodiversity can be increased through a variety of approaches including: plant diversity through the use of diversified crop rotations, cover crop mixes, diversity through the proper integration of grazing animals (e.g. livestock) into the system and includes animals living within the soils or microbial diversity, as well as direct additions with biological amendments. All four soil health management principles contribute to biodiversity.

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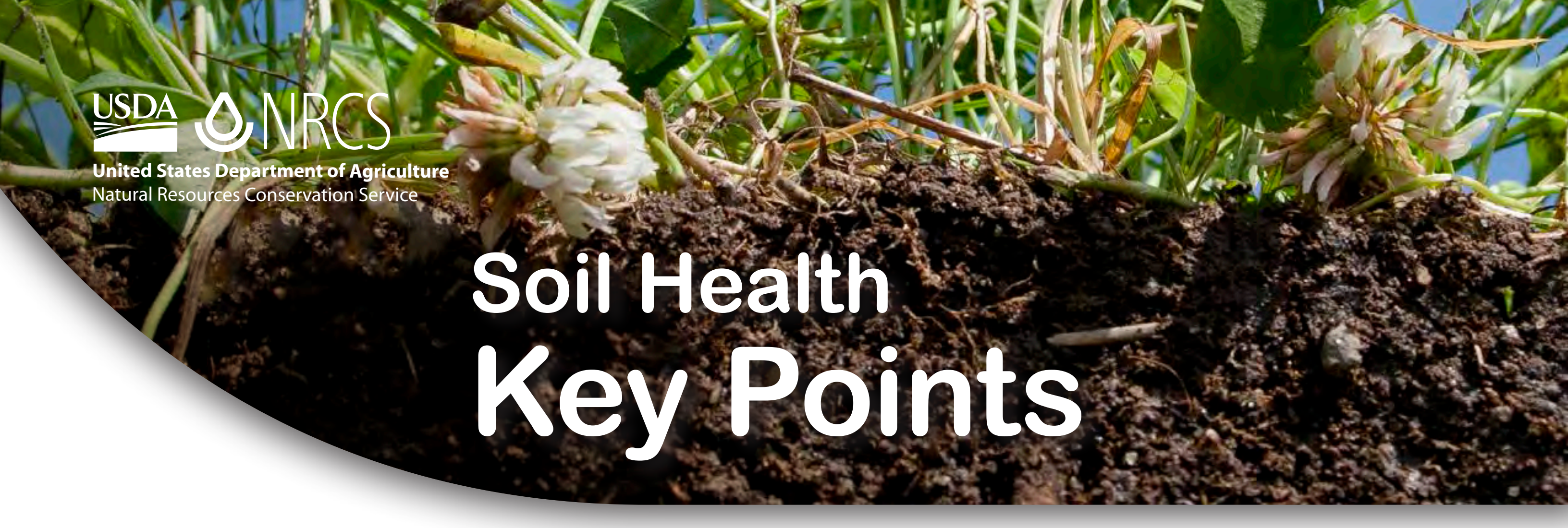

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Soil Health
Key Points

unlock the SECRETS IN THE SOIL

What's critical about soil health now?

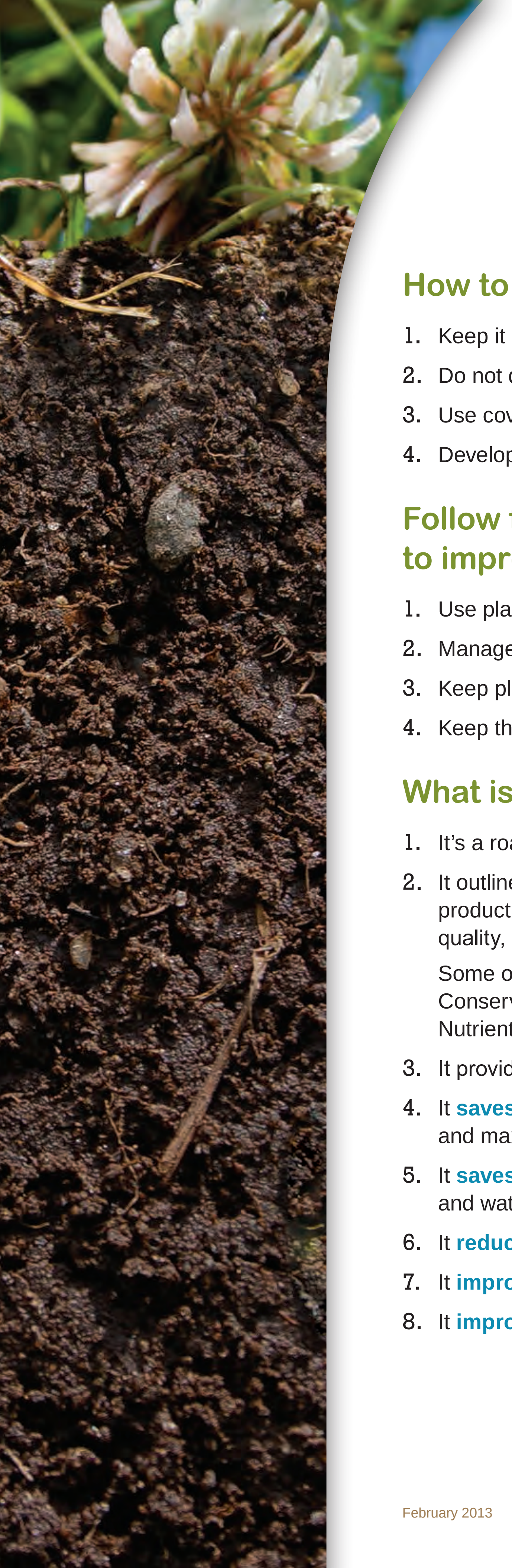
1. World population is projected to increase from 7 billion in 2013 to more than 9 billion in 2050. To sustain this level of growth, food production will need to rise by 70 percent.
2. Between 1982–2007, 14 million acres of prime farmland in the U.S. were lost to development.
3. Improving soil health is key to long-term, sustainable agricultural production.

Soil health matters because:

1. Healthy soils are high-performing, productive soils.
2. Healthy soils reduce production costs—and improve profits.
3. Healthy soils protect natural resources on **and** off the farm.
4. Franklin Roosevelt's statement, "The nation that destroys its soil destroys itself," is as true today as it was 75 years ago.
5. Healthy soils can reduce nutrient loading and sediment runoff, increase efficiencies, and sustain wildlife habitat.

What are the benefits of healthy soil?

1. Healthy soil holds more water (by binding it to organic matter), and loses less water to runoff and evaporation.
2. Organic matter builds as tillage declines and plants and residue cover the soil. Organic matter holds 18-20 times its weight in water and recycles nutrients for plants to use.
3. One percent of organic matter in the top six inches of soil would hold approximately 27,000 gallons of water per acre!
4. Most farmers can increase their soil organic matter in **three to 10 years** if they are motivated about adopting conservation practices to achieve this goal.



unlock the SECRETS IN THE SOIL

How to begin your path to Healthy Soils:

1. Keep it covered.
2. Do not disturb.
3. Use cover crops and rotation to feed your soil.
4. Develop a **soil health management plan** with the help of NRCS.

Follow four basic soil health principles to improve soil health and sustainability:

1. Use plant diversity to increase diversity in the soil.
2. Manage soils more by disturbing them less.
3. Keep plants growing throughout the year to feed the soil.
4. Keep the soil covered as much as possible.

What is a Soil Health Management Plan?

1. It's a roadmap to soil health.
2. It outlines a system of practices needed to enhance crop production and soil function, and improve or sustain water quality, air quality, energy efficiency and wildlife habitat.

   Some of the recommended conservation practices include: Conservation Crop Rotation, Cover Crops, No Till, Mulching, Nutrient Management, and Pest Management.
3. It provides environmental, economic, health, and societal benefits.
4. It **saves energy** by using less fuel for tillage, and maximizes nutrient cycling.
5. It **saves water** and increases drought tolerance by increasing infiltration and water holding capacity as soil organic matter increases.
6. It **reduces disease** and pest problems.
7. It **improves income sustainability** for farms and ranches.
8. It **improves plant health**.

February 2013

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healthy, productive soils checklist for growers

unlock the SECRETS IN THE SOIL

Managing for soil health is one of the best ways farmers can increase crop productivity while improving the environment.

Results are often realized immediately and last well into the future. Following are four basic principles to improving the health of your soil.

1. Keep the soil covered as much as possible
2. Disturb the soil as little as possible
3. Keep plants growing throughout the year to feed the soil
4. Diversify as much as possible using crop rotation and cover crops

Use the checklist on the back of this page to determine if you're using core Soil Health Management System farming practices. It is important to note that not all practices are applicable to all crops. Some operations will benefit from just one soil health practice while others may require additional practices for maximum benefit. These core practices form the basis of a Soil Health Management System that can help you optimize your inputs, protect against drought, and increase production.

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Soil Health Management Systems Include:

What is it?		What does it do?	How does it help?
Conservation Crop Rotation Growing a diverse number of crops in a planned sequence to increase soil organic matter and biodiversity in the soil.		• Increases nutrient cycling • Manages plant pests (weeds, insects, and diseases) • Reduces sheet, rill and wind erosion • Holds soil moisture • Adds diversity so soil microbes can thrive	• Improves nutrient use efficiency • Decreases use of pesticides • Improves water quality • Conserves water • Improves plant production
Cover Crop An un-harvested crop grown as part of planned rotation to provide conservation benefits to the soil.		• Increases soil organic matter • Prevents soil erosion • Conserves soil moisture • Increases nutrient cycling • Provides nitrogen for plant use • Suppresses weeds • Reduces compaction	• Improves crop production • Improves water quality • Conserves water • Improves nutrient use efficiency • Decreases use of pesticides • Improves water efficiency to crops
No Till A way of growing crops without disturbing the soil through tillage.		• Improves water holding capacity of soil • Increases organic matter • Reduces soil erosion • Reduces energy use • Decreases compaction	• Improves water efficiency • Conserves water • Improves crop production • Improves water quality • Saves renewable resources • Improves air quality • Increases productivity
Mulch Tillage Using tillage methods where the soil surface is disturbed but maintains a high level of crop residue on the surface.		• Reduces soil erosion from wind and rain • Increases soil moisture for plants • Reduces energy use • Increases soil organic matter	• Improves water quality • Conserves water • Saves renewable resources • Improves air quality • Improves crop production
Mulching Applying plant residues or other suitable materials to the soil surface to compensate for loss of residue due to excessive tillage.		• Reduces erosion from wind and rain • Moderates soil temperatures • Increases soil organic matter • Controls weeds • Conserves soil moisture • Reduces dust	• Improves water quality • Improves plant productivity • Increases crop production • Reduces pesticide usage • Conserves water • Improves air quality
Nutrient Management Managing soil nutrients to meet crop needs while minimizing the impact on the environment and the soil.		• Increases plant nutrient uptake • Improves the physical, chemical and biological properties of the soil • Budgets, supplies, and conserves nutrients for plant production • Reduces odors and nitrogen emissions	• Improves water quality • Improves plant production • Improves air quality
Pest Management Managing pests by following an ecological approach that promotes the growth of healthy plants with strong defenses, while increasing stress on pests and enhancing the habitat for beneficial organisms.		• Reduces pesticide risks to water quality • Reduces threat of chemicals entering the air • Decreases pesticide risk to pollinators and other beneficial organisms • Increases soil organic matter	• Improves water quality • Improves air quality • Increases plant pollination • Increases plant productivity

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unlock your farm's potential discover the cover

unlock the SECRETS IN THE SOIL

Biodiversity increases the success of most agricultural systems.

Biodiversity helps to prevent disease and pest problems associated with monocultures. Using cover crops and increasing diversity within crop rotations improves soil health and soil function, reduces costs, and increases profitability. Diversity above ground improves diversity below ground, which helps create healthy, productive soils.

Cover Crops

Cover crops can be an integral part of a cropping system. Cover crops can be managed to improve soil health, as they help to develop an environment that sustains and nourishes plants, soil microbes and beneficial insects.

Cover crops are typically planted in late summer or fall around harvest and before spring planting of the following year's crops. Examples of cover crops include rye, wheat, oats, clovers and other legumes, turnips, radishes, and triticale. Planting several cover crop species together in a mixture can increase their impact on soil health. Each cover crop provides its own set of benefits, so it's important to choose the right cover crop mixture to meet management goals.

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September 2012

Cover Crop Benefits

Restoring Soil Health – Cover crops help increase organic matter in the soil and improve overall soil health by adding living roots to the soil during more months of the year. Cover crops can improve water infiltration into the soil. Deep-rooted crops like forage radishes create natural water passages. Legume cover crops serve as natural fertilizers while grasses scavenge nutrients that are often lost after harvest or during winter.

Natural Resource Protection – Along with crop residue above ground, cover crops protect the soil against erosive heavy rains and strong winds. Cover crops trap excess nitrogen, keeping it from leaching into groundwater or running off into surface water – releasing it later to feed growing crops.

Livestock Feed – Cover crops can provide livestock producers with additional grazing or haying opportunities.

Wildlife Habitat – Cover crops provide winter food and cover for birds and other wildlife. During the growing season, they can provide food for pollinators.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems allow farmers to enjoy profits because they spend less on fuel and energy while benefiting from the higher crop yields resulting from improved soil conditions.

Contact your local NRCS office to learn more about Soil Health Management Systems and the technical and financial assistance available to help "Unlock the Secrets in the Soil."

Natural Resources Conservation Service

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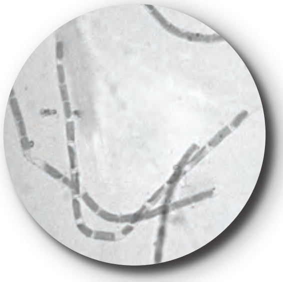
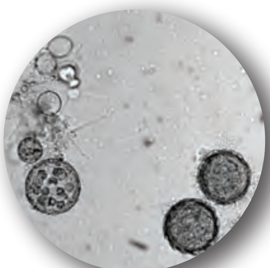
HEALTHY SOILS ARE: *full of life.*





MANY PEOPLE DON'T REALIZE THAT SOIL, ESPECIALLY HEALTHY SOIL, IS FULL OF LIFE.

Many people don't realize that soil, especially healthy soil, is full of life. Millions of species and billions of organisms make up a complex and diverse mix of microscopic and macroscopic life that represents the greatest concentration of biomass anywhere on the planet.

Bacteria, algae, microscopic insects, earthworms, beetles, ants, mites, and fungi are among them. All together, their value has been estimated at $1.5 trillion a year worldwide.

Estimates vary, but if you could weigh all the organisms in the top six inches of soil on an acre of land, you'd find they would weigh between 2,500 pounds to more than 5,000 pounds, depending on how healthy the soil is. That is a LOT of life.

What these low-lying creatures lack in size, they make up for in numbers. Consider bacteria, the soil microbes with the highest numbers, for example. You can fit 40 million of them on the end of one pin. In fact, there are more soil microorganisms (microbes for short) in a teaspoonful of soil than there are people on the earth.

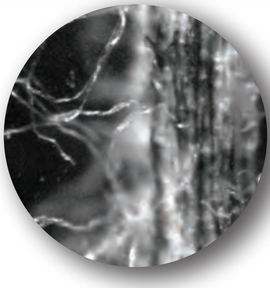
These microbes, which make up only one-half of one percent of the total soil mass, are the yeasts, algae, protozoa, bacteria, nematodes, and fungi that process soil into rich, dark, stable humus.

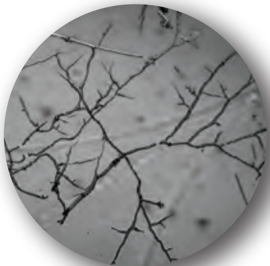
Like other living creatures, the organisms in the soil also need food and shelter. Some feed on dead organic matter, and some eat other microbes. As a group, they cycle nutrients, build the soil and give it structure.

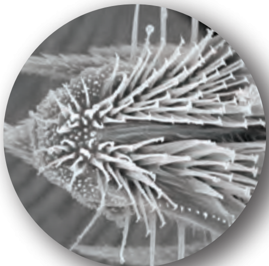
The healthiest soils are those with a diversity and abundance of life. Farmers with the healthiest soils nurture that life by creating a diversity of plant life above the soil surface, with year-round ground cover, no tillage, and judicious pesticide use.

unlock the SECRETS IN THE SOIL

HEALTHY SOILS ARE: *full of life.*







Fully realizing the soil is full of life is a game-changer for producers who are farming with healthy soils in mind. For those producers, farming centers around feeding the organisms that build healthy soils.

These farmers understand that tillage, the turning of the soil that has been the standard for growing crops for years and years, is disruptive to soil microbes and destructive to the soil system.

Instead, they disturb the soil as little as possible. And, they grow a diversity of living plants in the soil as much of the time as practical, covering the soil and offering food to soil microbes through living roots. Those soil organisms, in turn, cycle nutrients back to the plant, allowing it to grow and flourish.

It's a natural, symbiotic system that leads to healthy soils and more sustainable and profitable agriculture.

ORGANISM	WHAT DOES IT DO?
BACTERIA	Feed on organic matter, store and cycle nitrogen, and decompose pesticides.
FUNGI	Up to 3,000 species of fungi are in the soil. Some feed on dead organic matter like crop residues that are more difficult to break down–others are parasites that attack other microbes. Some fan out from the root to get more nutrients and hold more water for the plant, delivering nutrients to the plant in exchange for carbon.
PROTOZOA	Eat bacteria, fungi, and algae. When they eat bacteria, their main food source, they unlock nitrogen that's released into the soil environment slowly. They convert organic nitrogen to inorganic nitrogen that's available to plants.
MITES	Decompose and shred organic matter as an important part of the nitrogen cycle.
NEMATODES	These microscopic worms are an important part of the nitrogen cycle. Most are non-pathogenic and don't cause disease. They eat other organisms in the soil.
EARTHWORMS	Expel partially decomposed organic matter, produce nutrient-rich casts, and make lubricated tunnels that aid soil structure and water movement in the soil.

Note: It's important to know how these organisms contribute to building healthy soil, but it's also important to know what harms them. Both tillage and the non-judicious use of pesticides can harm these important organisms.

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HEALTHY SOILS ARE: *high in organic matter.*

Losing Organic Matter

Organic matter is vital to healthy soils, yet most modern agricultural operations are not managed in ways to retain high levels. Only half the original organic matter remains in most modern cultivated soils. In general, organic matter levels have fallen from 5-6 percent of the soil to less than 3 percent on most cropland soils.

Using tillage depletes organic matter. Each time the soil is tilled, oxygen is stirred into it, stimulating microbial action to decompose organic matter at an accelerated rate. As a matter of fact, when a woodland is cleared and planted or a prairie is plowed, most of the organic matter that was built over hundreds of years is lost within 10 years of tillage.

Combining frequent tillage with farming practices that leave little plant residue for soil microbes to eat (such as burning or removing crop residues) will lead to the depletion of organic matter.

unlock the SECRETS IN THE SOIL

ORGANIC MATTER *matters*. IN FACT, THERE MAY BE NO OTHER COMPONENT THAT'S MORE IMPORTANT TO A HEALTHY SOIL THAN ORGANIC MATTER.

The tiny fraction of soil composed of anything and everything that once lived—organic matter—is more than an indicator of healthy soils.

The carbon in organic matter is the main source of energy for the all-important soil microbes and is also the key for making nutrients available to plants. The list of positive influences high levels of organic matter have on healthy soils includes:

1. Provides a carbon and energy source for soil microbes
2. Stabilizes and holds soil particles together
3. Supplies, stores, and retains such nutrients as nitrogen, phosphorusand sulfur
4. Improves the soil's ability to store and move air and water
5. Contributes to lower soil bulk density and less compaction
6. Makes soil more friable, less sticky, and easier to work
7. Retains carbon from the atmosphere and other sources
8. Reduces the negative environmental effects of pesticides, heavy metals and other pollutants
9. Improves soil tilth in surface horizons
10. Increases water infiltration rates
11. Reduces crusting
12. Reduces water runoff
13. Encourages plant root development and penetration
14. Reduces soil erosion

HEALTHY SOILS ARE: *high in organic matter.*

Considering the long list of benefits organic matter has on soil health and crop production, increasing organic matter may well be the most important management step a producer can take to improve a farm's profitability and sustainability. In general, there are three ways to do that:

1. Increase the amount of plant and root production;
2. apply carbon-rich materials to the soil; and
3. use practices that slow rather than speed decomposition.

Cover crops, green manure crops, and perennial forage crops add organic matter, as do compost and manure. Growing crops and roots add biomass above and below the soil surface. However, not all that biomass is converted to soil organic matter—much of it is released as carbon dioxide and water. It can take 20,000 pounds of organic inputs such as crop residue to increase the actual soil organic matter from 4 percent to 5 percent.

Compost in particular breaks down more slowly and improves soil structure more quickly than other organic materials. Manure breaks down quickly to add nutrients for crops, but takes longer to improve the soil than compost.

COMPARING ACTIVE AND STABILIZED ORGANIC MATTER

	PORTION OF ALL ORGANIC MATTER	DECOMPOSITION TIME	FUNCTIONAL IMPORTANCE
ACTIVE	One-half to two-thirds	Up to several decades	Decomposes organic material to produce plant nutrients
STABILIZED	One-third to one-half	A century or more	Exceptional water holding capacity, soil structure **benefits; reservoir** for nutrients, including carbon

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Active and Stabilized Organic Matter

Organic matter can be divided into two categories: active and stabilized. The portion made of fresh organic material and living organisms, as well as partially decomposed material that is slowly decomposing, is called "active organic matter."

Active organic matter and the microbes that feed on it are central to nutrient cycles in the soil. Nutrients, especially nitrogen, phosphorus, and sulfur, are held in this active organic matter until soil organisms release them for plant use.

This accounts for there being much more nutrient volume in the soil than is available for plant use at any one time. For example, a soil with 3 percent organic matter contains about 3,000 pounds per acre of nitrogen, but only a small part of that (30-100 pounds) may become available to plants in any one year, depending on decomposition rates.

While active organic matter may decompose over a few decades, the stabilized portion of organic matter is made of larger, more complex compounds that are much more difficult for microbes to degrade. Much of the stabilized organic matter in the soil is highly decomposed plant and animal tissues that grew more than a century, and possibly several centuries, ago. This organic matter becomes carbon-rich humus that's resistant to further decay.

"Stabilized organic matter" or humus, acts like a sponge and can absorb six times its weight in water. It's also a reservoir for nutrient storage, sequestering carbon from the atmosphere and other sources.

Healthy soils need both active and stabilized organic matter to function well.

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HEALTHY SOILS ARE: *well-structured.*

Give it the Slake Test!

Does your soil have good structure? Give it the slake test! Ray Archuleta, an agronomist with the USDA Natural Resources Conservation Service with a passion for soil health, has done the test scores of times. Anyone can do it, he says, and he predicts it will open your eyes.

"What happens with poor soil structure is that the pores collapse in water and the soil breaks apart," Archuleta says. "Soil with good structure—the untilled soil—can still be intact for the most part even 24 hours later. The reason for the difference is soil structure. Biological cementing, the work of soil microbes, glues the aggregates of the untilled soils together."

In a similar test, an infiltration or rainfall simulation test, Archuleta puts the two soil samples in wire mesh inserted into empty jars, then simulates rainfall onto them.

"When you put a tilled soil and an un-tilled soil in yarn jars and simulate rainfall onto them, you quickly see the untilled soil allows the water to infiltrate the whole profile. On the other hand, water stays on top of the tilled soil much longer," Archuleta says.

Continued on back

"SOFT AND CRUMBLY." "LIKE COTTAGE CHEESE." "LIKE A SPONGE." "LOOSE AND FULL OF HOLES."

Those and other common descriptions of what healthy soil looks and feels like refer to good soil structure.

Soil structure, the arrangement of the solid parts of the soil and the pore space between them, is critical to how the soil functions. When the solid parts—sand, silt and clay particles—cling together as coarse, granular aggregates, the soil has a good balance of solid parts and pore space.

Highly aggregated soils—those granular, durable, distinct aggregates in the topsoil that leave large pore spaces between them—are soils with good tilth and good structure.

Well-structured soils have both macropores (large soil pores generally greater than 0.08 mm in diameter) and micropores (small soil pores with diameters less than 0.08 mm that are usually found within structural aggregates).

An interconnected network of pores associated with loosely packed, crumbly, highly aggregated soils allows rapid infiltration and easy movement of both water and air through the soil and provides habitat for soil organisms.

Chemical and physical factors play a prominent role in small aggregate formation in clay soils, while biological processes drive development of large aggregates and macropores. Earthworms, for instance, produce both new aggregates and pores. Their binding agents are responsible for the formation of water-stable, macro-aggregates, and their burrowing creates continuous pores linking surface to subsurface soil layers. As they feed, earthworms also speed plant residue decomposition, nutrient cycling, and redistribution of nutrients in the soil profile.

HEALTHY SOILS ARE: *well-structured.*

Soil organic matter also helps develop stable soil aggregates. Soil microorganisms that are fed with organic matter secrete a gooey protein called glomalin, an effective short-term cementing agent for large aggregates. Organic glues are produced by fungi and bacteria as they decompose plant residues. Water-resistant substances produced by microorganisms, roots, and other organic matter, provide long-term aggregate stability from a few months to a few years.

TILAGE DESTROYS STRUCTURE

Management practices that reduce soil cover, disrupt continuous pore space, compact soil, or reduce soil organic matter, negatively impact soil structure. Since tillage negatively affects all of these properties, it's high on the list of practices damaging to healthy soils.

When tillage loosens the soil, it leaves soil particles exposed to the forces of wind and water. Transported by wind and water, detached soil particles settle into pores, causing surface sealing, compaction and reduced infiltration. When this happens less water is available to plants and runoff and erosion increases.

By contrast, soils that are not tilled and are covered with diverse, high residue crops throughout the year have better soil structure, are highly aggregated, with high levels of organic matter and microorganism activity, high water holding capacity, high infiltration rates, and little compaction.

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"I think these tests are powerful visual tools to help explain and help people remember how soils function" Archuleta continues. "I used to think if I tilled the soil—fluffed it up—it would allow more water in. But that's just not true. Tilling soil closes pore space and keeps rainfall from infiltrating. You've got to have pore space in your soil from top to bottom."

"The tests tell me in our watersheds we have an infiltration problem, not a runoff problem," he concludes. "What I mean is, if we focus on building healthy soils that result in more infiltration, we'll do what we need to do to eliminate much of the runoff."

How to do the Slake Test

The slake test compares two chunks of topsoil in water to see how well and how long they will hold together. Here are the steps:

1. Collect a chunk of topsoil—a size that would fit in your hand—from an area where you don't till, like a fencerow, or a field you've no-tilled or had in grass for many years.
2. Get a second spade-full or chunk of soil from a field you've tilled consistently. It should be the same soil type as the first sample.
3. Find two glass jars, yarn jars or some kind of clear glass jars large enough to hold the chunks of soil.
4. Put together some type of wire mesh that you can hook at the top of each jar that will allow the soil to be submerged in the water, yet be held within the top half of the jar.
5. Insert the wire meshes into each jar.
6. Fill the jars with water.
7. At the same time, submerge the tilled sample in one jar, and the untilled sample in the other.
8. Watch to see which soil holds together and which one falls apart. The soil with poor structure is the one that will begin to fall apart.

SOIL HEALTH NUGGETS

There are some *amazing* things going on underground...

Here are some things you may not know...

1. There are more soil microorganisms in a teaspoon of healthy soil than there are people on the earth!

Millions of species and billions of organisms—bacteria, algae, microscopic insects, earthworms, beetles, ants, mites, fungi and more—represent the greatest concentration of biomass anywhere on the planet! Microbes, which make up only one half of one percent of the total soil mass, are the yeasts, algae, protozoa, bacteria, nematodes, and fungi that process organic matter into rich, dark, stable humus in the soil.

2. The best soil on most farms is found in the fence row.

These undisturbed remnants of what soil properties were once like is no surprise to farmers who have dug into that soil. It's crumbly, dark, and loose, and it's a model of soil structure and organic matter for farmers who are trying to make their soil healthier.

3. Tillage (or plowing) destroys the soil's structure!

Tillage destroys "aggregation" or the soil's structure – the habitat soil microorganisms depend upon to ensure critical soil functions like nutrient cycling. Tillage also reduces organic matter content and increases erosion, which reduces the sustainability of our food production system.

4. Tilling the soil up does NOT allow more water to soak into it.

Don't believe it? Fill two containers with untilled and tilled soil and simulate rainfall on them. Watch the water stand on top of the tilled sample, but soak down through the untilled sample. Or, give them the slake test (placing clods of untilled and tilled soils on wire mesh at the top of water filled jars). You'll find if you submerge tilled soil just below the surface it will soon collapse in a heap at the bottom of the jar, but untilled soil will still be intact for the most part even 24 hours later. Tilling soils causes pores to collapse and seal over, causing more rain to runoff than soak in.

unlock the SECRETS IN THE SOIL

5.

OMG! Organic Matter (half) Gone!

The Morrow Plots on the campus of the University of Illinois indicate soil organic matter content in prairie grass borders was 5.5 to 6.5 percent in 1876. Less than half of that is left. That's the case with most prairie soils—oxidation of organic matter from tillage for row crops has reduced organic matter levels to between 2 - 3 percent today.

6.

A farmer's favorite cocktail mix might not be what you think.

Innovative farmers are breathing new life into their soil by seeding a "cocktail mix" of 6-12 plants to get diversity above-ground, which creates much-needed diversity below the ground. Through that diversity, farmers are mimicking the soil-building and microbial-friendly conditions of the diverse native prairies.

7.

If you want your soil to be healthy, you shouldn't see it very often.

That's because you want that soil to be covered all the time, preferably with living plants. Keeping the soil covered all the time makes perfect sense when you realize that healthy soils are full of life. The microorganisms living in the soil need food and cover to survive – just like other living creatures.

8.

Roots of some plants can grow 3-feet deep in 60 days!

That's right, roots of daikon type radishes are a biological alternative to deep ripping to alleviate soil compaction. After radishes winter kill the channels created by the roots tend to remain open at the surface, improving infiltration, surface drainage and soil warming. The popular cover crop also is an excellent nitrogen scavenger.

9.

What did President Thomas Jefferson know that we don't?

More than 200 years ago, Thomas Jefferson, a farmer and conservationist, used vetch, turnips, peas, and clover as cover crops and in rotation. He used these crops on his Virginia plantation to build soil that he knew was being depleted with his tobacco cash crop.

10.

Multiple "bennies" through multiple species.

The below-ground synergy created by crop rotations and multi-species cover crops can actually accelerate biological time by increasing organic matter, allowing crops to flourish in dry times while monocultures struggle. And as an added bonus, diverse cover crop mixtures work together to crowd out weeds, improve nutrient cycling and reduce plant diseases.

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