Building Healthy Soil

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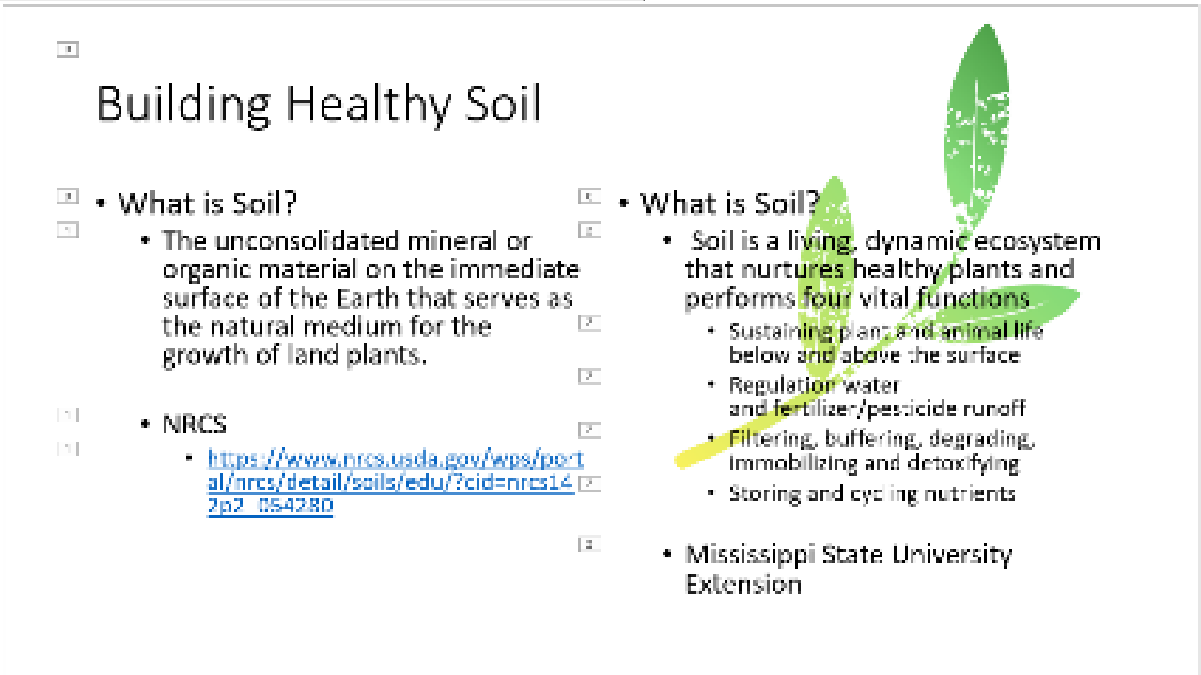
Building Healthy Soil

Before we talk about building healthy soil, we need to understand the basic components, structures, and functions of soil.

There are probably as many different definitions of soil as there are types of soil. Many of those definitions are technical, stemming from academic research or scientific literature. On the other end of the spectrum are definitions stemming from a more spiritual frame of reference. In between, the definitions tend to be colored by the experiences of the person offering the definition.



QUESTION – WHAT IS SOIL?

Soil

I have two definitions. One from a scientific perspective and one from the perspective of gardeners and farmers.

- What is Soil?
    - The unconsolidated mineral or organic material on the immediate surface of the Earth that serves as the natural medium for the growth of land plants.
- What is Soil?
    - Soil is a living, dynamic ecosystem that nurtures healthy plants and performs four vital functions
        - Sustaining plant and animal life below and above the surface
        - Regulation water and fertilizer/pesticide runoff
        - Filtering, buffering, degrading, immobilizing and detoxifying
        - Storing and cycling nutrients

Let's look at the first definition. It is descriptive but lacks more than a passing reference to what soil does more than cover the immediate surface of the earth.

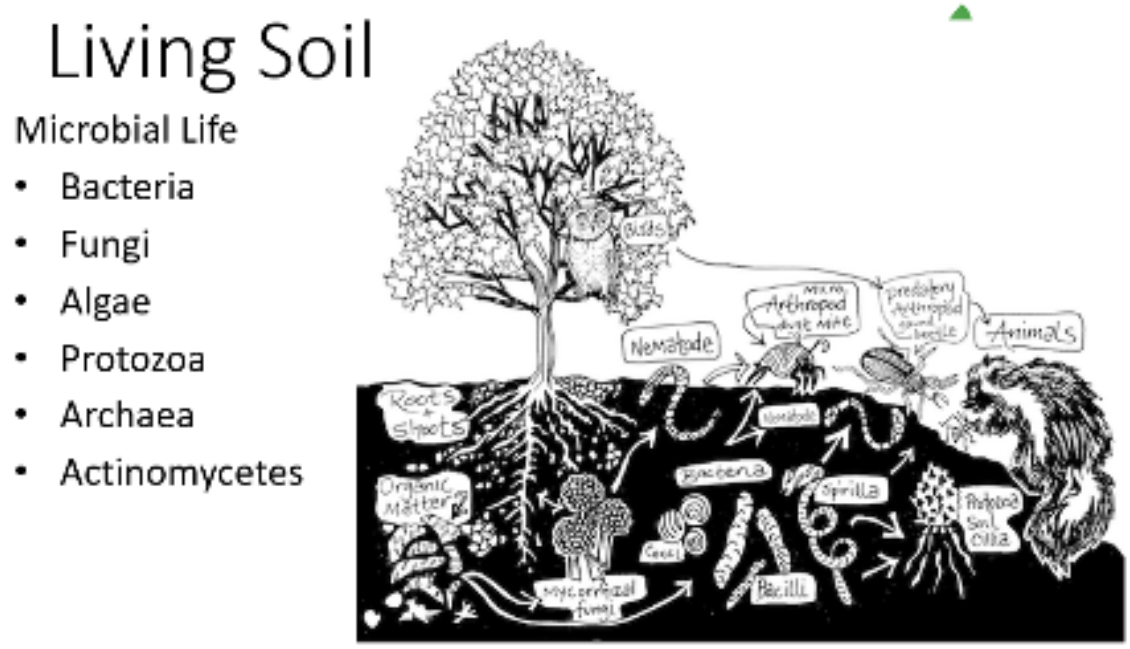
In contrast, the second definition, which comes from the Mississippi State University Extension Service, is much more directed to the functions of soil. In particular the word "

Looking at that word gives us an even clearer understanding of soil.

"The sum of the environmental factors influencing the behavior and traits expressed by an organism" (Merriam-Webster, n.d.)

That one word sums up the philosophy that I take toward the soil. Soil is the basis of all terrestrial life on earth. The health of every land-based animal, humans included, is directly tied to the health of the soil.

There are many who would argue that soil is not a living organism. Those who take that point of view argue that soil is simply the structural component that hosts the vast numbers of other organisms that exist within the soil. No matter which side of the argument you chose, the fact remains that without a healthy soil biome, it is almost impossible to have a sustainable system of life.



Living Soil – Microscopic Life

WHAT MAKES UP LIVING SOIL?

Let's take a look at just a few of the organisms we expect to find in healthy soil. First, let's look at those that we can't see, the microscopic life. It is far more numerous and far more robust than most of us realize.

Perhaps the most numerous organisms found in healthy oil are the bacteria. Estimates are that an acre of soil contains enough bacteria to weigh a ton, 2000 lbs. Considering that the average bacteria weigh about one picogram, that is an amazing amount of bacteria. A picogram is a decimal with 13 zeros and then a 1.

There are thousands of different varieties of bacteria in the soil, each performing a different function. Most are beneficial. Some are not, and these are the ones we label pathogens. In healthy soil, healthy bacteria keep the pathogens in check, and a balance is maintained.

Fungi are the other heavy lifters in the soil biome. Fungi are long cells that exhibit a hairlike structure called hyphae that can extend for many meters in the soil. Fungi serve roles in decomposing, nutrient management and movement, water management, soil creation, and structuring and pathogen suppression.

Fungi form symbiotic relationships with plants and plant roots and act as agents for the plants in the acquisition of moisture and nutrients.

Algae

Algae exist in healthy soil in abundance. It can only exist when there is adequate soil moisture. Algae provide a rich source of nutrients for the smaller creatures in the soil as well as encouraging root mass and are a major means of sequestering carbon in the soil.

Protozoa

Protozoa are single-cell animals that prey mostly on bacteria. Protozoa are important in the soil food web for many reasons, but one of the most important is the nitrogen they release when they consume bacteria. This nitrogen is one of the major sources of plant-available nitrogen in the soil, so a healthy community of protozoa is important in the soil food web.

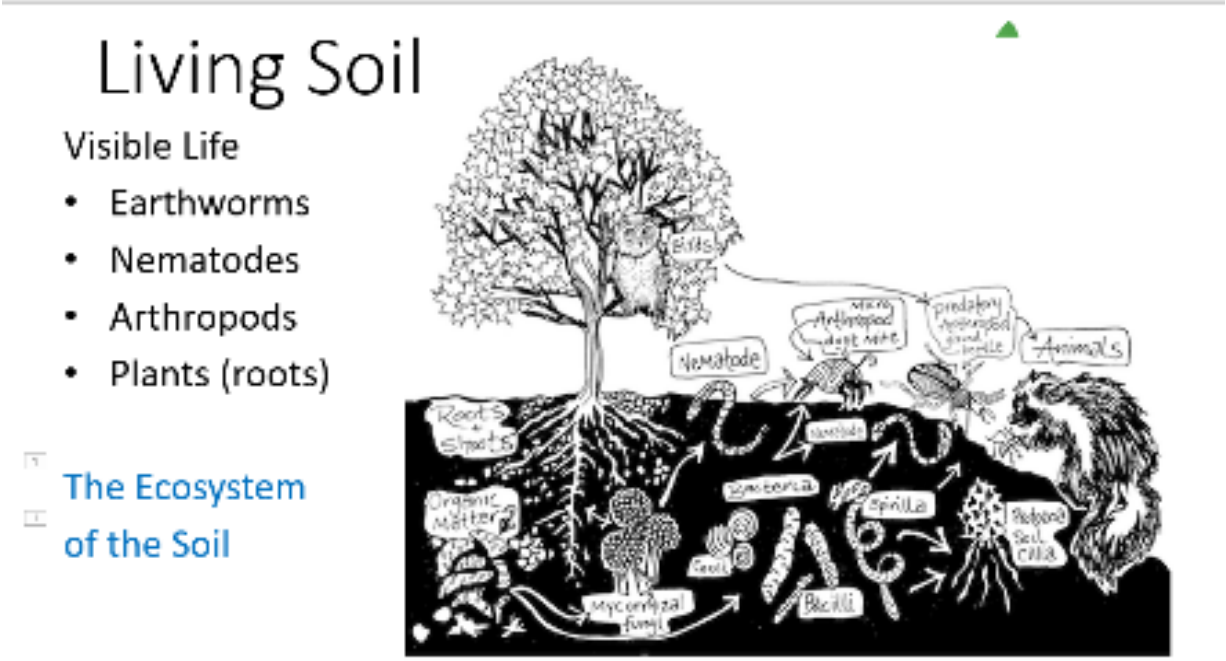
Archaea

Archaea are a relatively discovery in soil biology. Not much is known about them as they have so far proven impossible or extremely difficult to culture in the lab for study. For many years, archaea were thought to be a different species of bacteria, but most microbiologists now consider them a completely different animal.

Actinomycetes

These are a different strain of bacteria which specialize in decomposing harder to attack organic materials such as chitin, the organic material that makes up the outer skeleton of most insects. Actinomycetes are filament-forming bacteria (mycelium) forming bacteria, unlike most of the other bacteria found in the soil.

Together these microscopic organisms form a rich and diverse community that performs so many essential functions in the soil that they are almost impossible to classify and reference. May are symbiotic. Working together as a system, they perform functions to create soil, structure and manage soil, and work with plants to maintain a healthy soil food web.



Living Soil – Visible Life

THERE ARE FOUR OF THESE, CAN ANYONE GUESS WHAT THEY ARE?

Earthworms

Earthworms are the composters of the soil world. Each earthworm, during its life, will consume and move hundreds of pounds of organic matter and producing the purest and best form of compost that can be had. In the soil, these worm castings become the basis of nutrient-rich soil.

Consuming bacteria and fungi that exist on the surface of organic matter undergoing decay in the soil, the earthworm converts this biomass into plant-available nutrients.

Earthworms can dramatically alter soil structures and are an excellent indicator of soil health. Their constant movement in the soil opens the soil structure for water and air infiltration. Their castings

deposit nutrient-rich deposits in the soil. A lack of earthworms in your soil not necessarily an indication of poor soil health, but it should raise questions.

Some sources expect a shovel full of healthy soil to contain 4 to 8 earthworms.

Nematodes

Nematodes are small non-segmented worms that live in the soil at multiple levels. Most nematodes are about 1/20th of an inch long, just barely visible to someone with extremely good eyesight. Nematodes, as a whole, have gotten a bad reputation from a few species that are pathogenic. We all are familiar with nematodes that attach the roots of certain plants, causing stunted growth. Of the vast number of nematodes, these pathogenic varieties are in the minority. The vast majority of nematodes perform beneficial functions. These varieties eat bacteria, protozoa, and fungi, releasing nutrients into the soil. Other varieties prey on other nematodes, especially the harmful varieties providing natural control and balance.

Arthropods

Arthropod is a fancy scientific name for bugs. Many bugs spend at least part of their life cycle in the soil. Many lay their eggs in the soil. Some spend a part of their larval cycle in the soil, and some spend their entire life cycle in the soil.

Bugs can range in size from nearly microscopic to an inch or more in length. They include springtails, beetles, ants, spiders, and a vast number of others. Bugs are part of the decomposing cycle. Bugs break down the larger pieces of organic material as they feed. Their drippings become material for the smaller organisms in the soil food web.

Plants

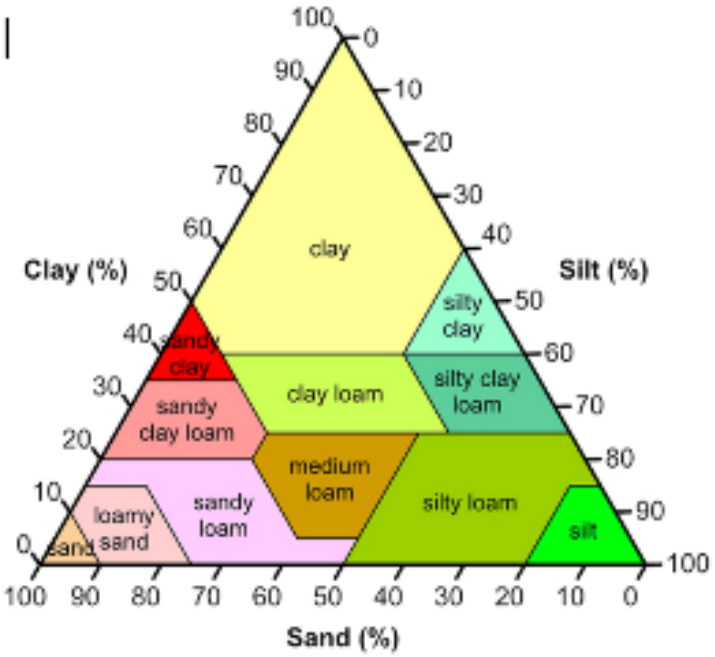
Yes, plants exist as part of the soil biome. Plants have two parts, those above the soil level and those below. The plant roots are part of the soil food web. When living, they interact with the other inhabitants of the soil web. Plant roots communicate and associate with bacteria and fungi through the exudates they produce. When dead, the plant roots become another source of nutrients for the members of the soil food web who consume them and return those stored nutrients to the soil.

That is a basic introduction to the soil ecosystem or the soil food web. It is a dynamic living system, intricate in its design and elegant in its function. When balanced and healthy, nothing goes to waste. It is the perfect recycling system at work.

Building Healthy Soil

Soil Components

- Clay
  - Sticky and somewhat coarse
- Silt
  - Slick and smooth
- Sand
  - Gritty and coarse



Soil Components

Technically we are speaking here of soil texture, but it is easier to think of this as percentages of the three main components of soil – clay, silt, and sand.

Looking at the triangle, the texture of the soil is a composite of the three components. The big question is, how do we determine what percentage of these three components make up our soil. The easiest way to do a feel test. Feeling your soil will give you a rough idea of the makeup of your soil. It is important to understand the individual characteristics of the three components

Clay

Pure clay, when slightly damp, will feel sticky. I think we have all had some experience with clay and know the feeling of wet clay sticking to our shoes and our hands. Clay soils, when wet, are those that you tend to sink into and then pull your shoes off when you try to lift your feet.

When touch testing a soil sample, a sticky somewhat coarse feeling is a good indicator of soil heavy in clay.

Silt.

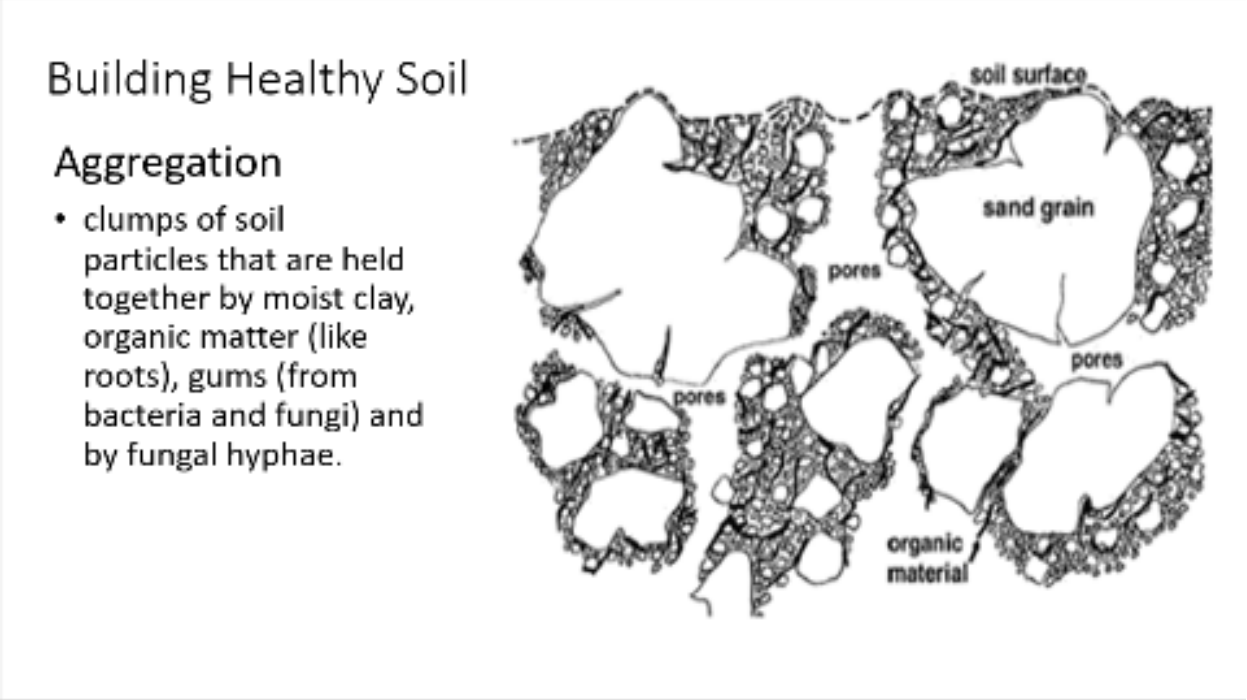
Silt is the finest particles of soil that we can find. The best example if four. The very fine particles of flour are similar to silt, and when wet, the flour feels slick and smooth to the touch. Silt in soil exhibits

the same characteristics and the same feel. Soils with a large silt base will feel slick and smooth to the touch.

Sand

Everyone should know sand when they feel it. Think of salt when you rub it between your fingers. If you have been to the beach and spent any time, you know the feeling of sand in your swimsuit or shoes. Soil rich in the sand has that same gritty and coarse feel.

There are several good websites, especially the NRCS website that has step by step flow charts that will take you through doing a feel test on your soil. There are other soil tests you can do at home to determine the percentage of each type of soil component. Links to these resources are available on our website.



Soil Aggregation

The parts of soil, clay, silt, and sand, have different properties and characteristics when combined in the soil. They are different sizes and react differently to water and air.

Many of the problems we associate with unhealthy soil are due to the formation of structures due to these characteristics. Perhaps the most well known is the crusting or caking of surface soil after a rain event of irrigation. We have all experienced it. Water hits the soil, and some soaks in, and then it

begins to puddle and eventually begins to run off. The running water begins to cut channels and furrows, not to mention carrying away topsoil. We commonly refer to this as surface soil erosion.

Most of this problem can be directly related to soil health and the lack of adequate subsoil life.

Importance of Aggregation

In healthy soil, the sub-soil life causes the individual parts of the soil to form lumps and clumps called aggregates. These can exist from microscopic to the barely visible. These aggregates vary in shape and size, but their importance is huge.

The soil components are held together by moisture, organic matter, fungal hyphae, and glomalin. Glomalin is a glue-like substance that is produced by the soil fungi and bonds these soil particles together.

Water Infiltration

Water infiltration in the soil is the measurement of how much water will enter the soil in a given amount of time, usually measured in inches per hour.

Infiltration rates are dependent on soil particle size. In unaggregated soil, the soil component in the greatest percentage tends to control the water infiltration rate. Sane usually infiltrates faster than the others with clay being next and silt coming in last.

The same holds for aggregated soils, but instead of the component size being the issue, it is the size of the aggregates that are the controlling factor. The larger the aggregates and the spaces between them, the higher the infiltration rate.

Since healthy soil is, by definition, a soil that is well aggregated, we would expect a higher infiltration rate.

Compaction and Crusting

Soil compaction is a major problem in unhealthy soil that has little or no aggregation. The individual component parts of the soil, when wet, nest together and form hard, compact structures that resist water infiltration and cause puddling and sheeting of water. This leads to erosion and the loss of topsoil.

Erosion Control.

Well aggregated soil exhibits far less erosion that unhealthy unaggregated topsoil. Even in areas where plant growth is established in soils that remain unaggregated, these soils tend to erode and wash despite the presence of root structures in the soil.

Microbial and sub-surface life support

Aggregated soils form voids, channels, and pockets between the aggregates. These voids and channels provide the living and working space for the sub-surface soil life. Thes channels and spaces trap and hold moisture, allow bacterial and fungi colonies to grow, create pathways for protozoa, and arthropods to move and are the primary means of water infiltration.

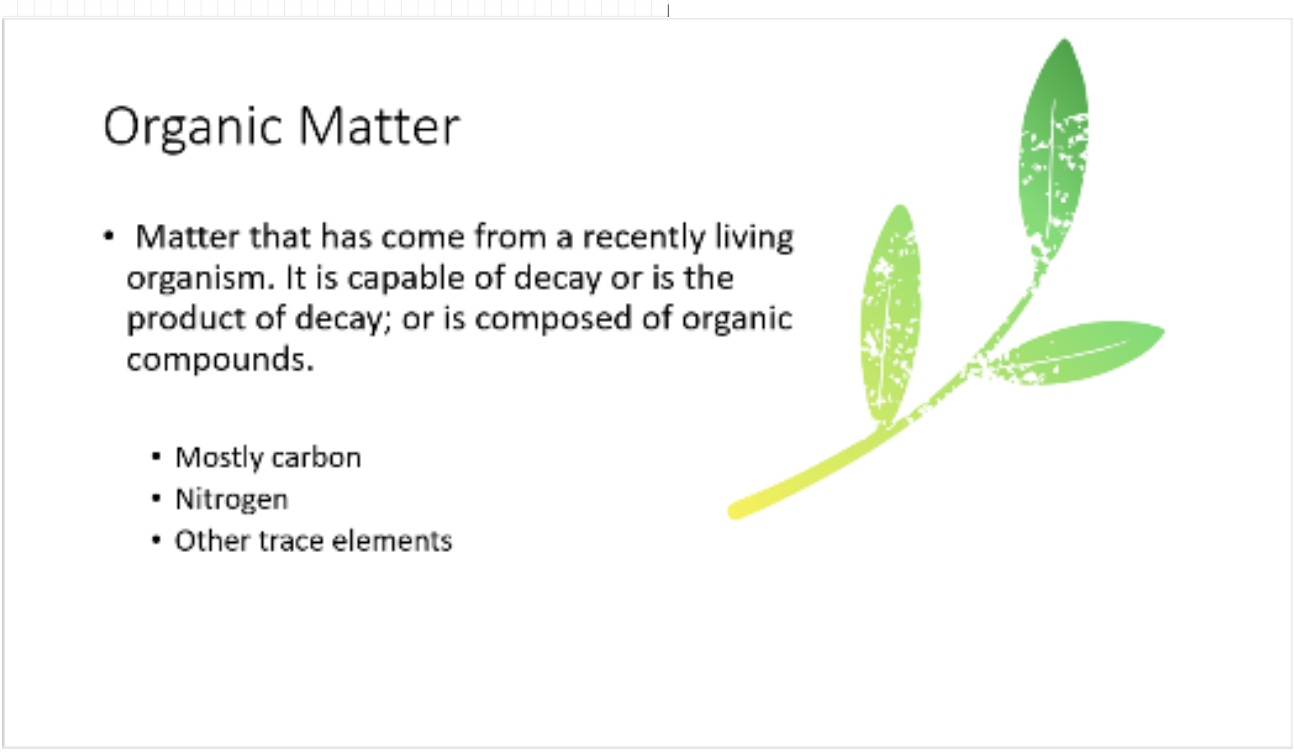
The importance of aggregation cannot be overstated. When soil aggregates form, they create voids and spaces in the soil. It is through these voids and spaces that water infiltrates the soil and brings fresh air into the subsoil. Even the smallest bacteria in the soil need three things to live, water, air, and food. The spaces formed by the aggregates provide the moist spaces in which bacteria, fungi, protozoa, and arthropods live and work.

Without aggregates, the soil becomes compacted, and the individual parts of the soil begin to exhibit their characteristics. When the soil compacts, the other organisms in the soil cannot find the things they need to function, and they disappear. With those organisms, the soil cannot aggregate.

Nutrient Management

Many nutrients found in the soil that are necessary for plant health, tend to be highly mobile. They will leach downward in the soil in the presence of water to depths that put them out of reach of plants and fungi hyphae. Eventually, these nutrients end up in the subsurface water tables and can become a source of pollution.

The aggregate structures in soil help hold these nutrients in place, keeping them available for the plants and out of the water system.



Organic Matter

QUICK! WHAT IS ORGANIC MATTER?

Organic Matter

- Matter that has come from a recently living organism. It is capable of decay or is the product of decay; or is composed of organic compounds.

So, anything that has once been alive is considered organic matter. In a gardening sense, we are often told to amend our soil with generous amounts of organic matter. The real question is, how do we do that effectively and efficiently.

We need to understand the makeup of organic matter.

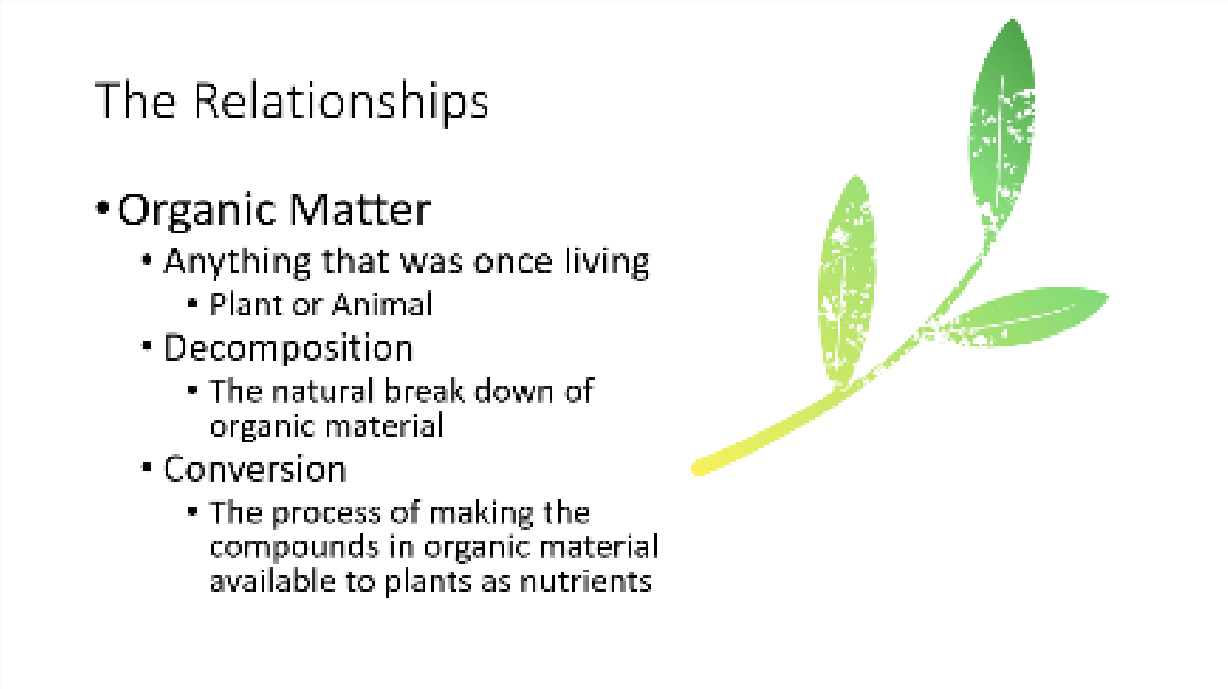
(MOUSE)

Organic matter, first and foremost, is made up of carbon. We are a carbon-based world. Nitrogen is also a huge part of organic matter. Last, but by no means least, are the trace elements that are essential

to life. What is being said is that to create and maintain healthy soil, we need to add a multitude of things. Not only do we need to provide these things in the soil to the plants and other organisms, but they also need to be added in the right proportions.

The most efficient way to do this is to incorporate the remains of once-living things back into the soil.

If you think about it, this makes sense. Nature is amazing. The remains of all those plants in your garden already contain those very nutrients, in the precise proportion the plant needed when it was alive. Once incorporated back into the soil and decomposed, those nutrients exist in the soil in those proportions.



The Relationships

How does all this fit together? What are the relationships?

Organic Matter

Organic matter is anything once living, plant, or animal.

Decomposition

The natural break down of organic matter

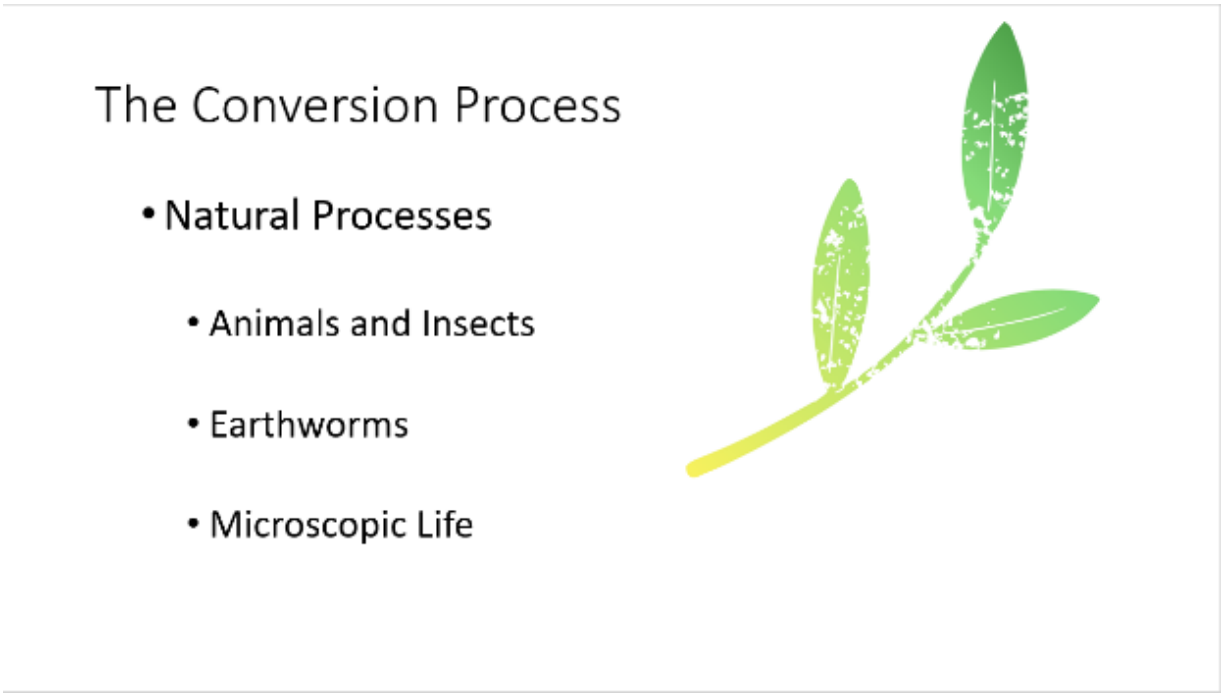
Decay

Rot

Decomposition

Conversion

The process of making the compounds in organic material available to plants as nutrients

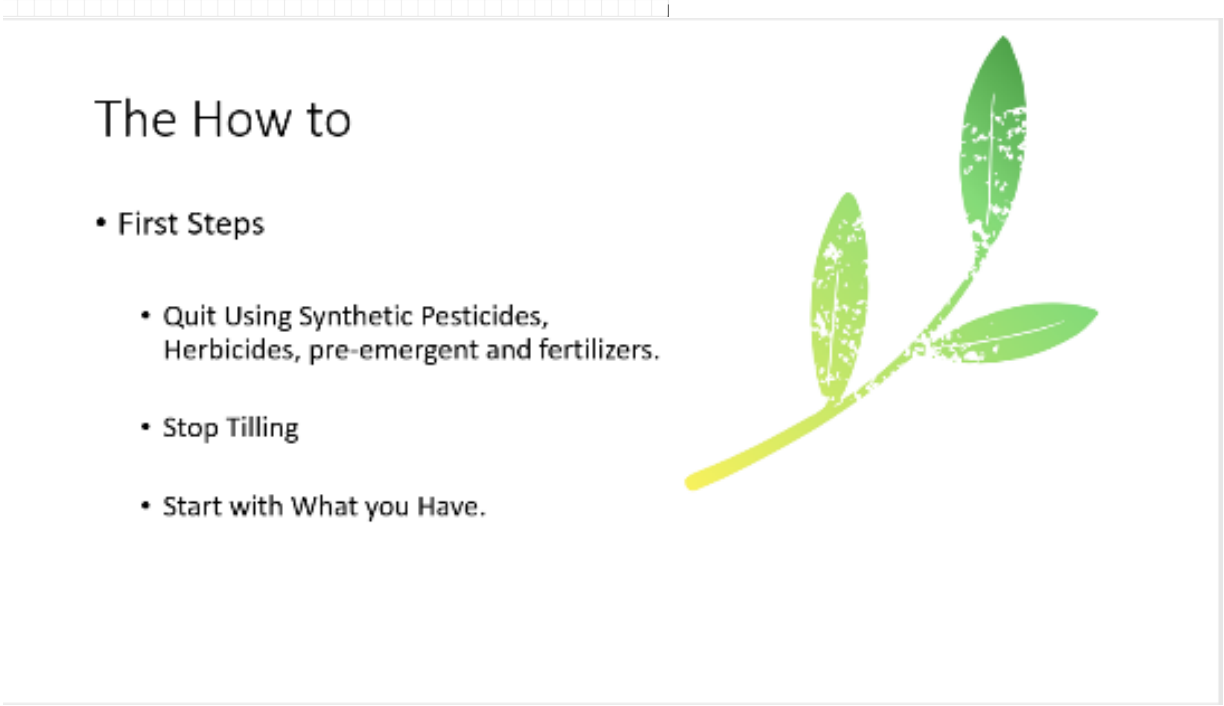


The Conversion Process

The basic process of conversion are all dependent on the soil food network including the larger actors in this system

Animals often begin the process but eating what is viable for them. Their excrement becomes part of the process as the other members of the soil food web continue the conversion process. Insects get into this act as do other forms of life. As the parts of the biomass become smaller and smaller, it gets to the point that even the microscope creatures are the major factors.

There is no escaping the process outside some extraordinary steps. The whole process is like one complicated and long circular chain of linked segments, many of which are interlinked in other ways. It is a vastly complicated system and elegant in its methods and outcomes.



The How-To

We are finally getting to the part of this presentation that you all came for — the how-to portion of building healthy soil.

You had to endure all the other stuff, so I could fill time and make you feel like you were getting what you expected. The truth of the matter is that building healthy soil is, for the most part, easy. There are three priority steps that you must take to begin building healthy soil in your garden and landscape.

FIRST -- Stop using artificial synthetic products on your soil and plants. Pesticides, herbicides, pre-emergents, and fertilizers are the biggest problem with soil health.

Pesticides. We want to control the pests in our garden and landscape. You must first accept that these pests are part of the ecological life of the biome and, in some inexplicable manner, have a place and a reason for existing. In a healthy ecosystem, other members of the biome serve as controls on the pests, and a balance exists. It is when we attempt to interfere with the balance that things go awry.

The other thing to continue, most of the pesticides are non-specific. They kill not just the pests, but also any other insect or bug that comes into contact with the product. That includes all the beneficial flying and living in your garden, or that visit your garden. This goes for the sub-soil parts of this system. Bacteria, protozoa, and fungi are all living creatures, and most of them react badly to the introduction of any insecticide into the soil. Earthworms are also susceptible to the poisons in use to control insect pests.

Herbicides have the same effects. Many protozoa and algae are affected negatively by herbicides.

Pre-emergent are just herbicides that target seeds before they germinate or shortly after they germinate. They will also do the same for subsurface flora and fauna

And Fertilizers. There is so much to say for the negative effects of salt-based synthetic fertilizers on soil health that I don't have time or space to treat the subject adequately. There is just too much to cover. The addition of salts to the soil. The impact of excessive amounts of nitrogen, phosphorus, and potassium on the relationships between the soil organisms and the plants is enough for me to carry on for hours. Synthetic fertilizers help destroy the healthy relationships between the soil biome and plants, creating a vicious circle in which more and more fertilizers are required, pesticides and herbicides use increases to control pests and invasives that flourish when plants become stressed and natural predators and controls are diminished.

Stop Tilling

Tilling destroys the soil structure and the soil organisms in the area that is disturbed. The network of fungi hyphae is broken, and the spaces required for the bacteria, fungi, and other organisms to grow are removed from the soil. The aggregates in the soil are disturbed, and without a healthy soil biome, there is no way for them to reform. Tilling almost guarantees that your soil will begin to compact and crust and that you will lose the tilth of your soil.

Start with What you Have

Don't believe that your only recourse is to bring on tons of new topsoil to build healthy soil in your garden. In almost every instance I have experienced, there was nothing wrong with the existing soil that could not be fixed with some basic attention.

Bringing in new topsoil can create its problems. If it is properly composted, it is almost devoid of life anyway. The temperatures to which properly composted topsoil reach are deadly to all the organisms we are trying to encourage. You may, inadvertently, bring in other problems as well.

Following the steps outlined below will regenerate soil in a healthy and safe manner.

Building Soil – Amendments

These are all-natural and organic soil amendments that we use regularly. Most are readily accessible from most garden centers or nurseries.

Compost

Compost is our most used and most recommended soil amendment. We use it regularly to amend the soil in garden beds and our turf. We use it in preparing potting soils and container soils. It is the primary component in compost tea, which we spray liberally as a foliar fertilizer and as a drench on our garden beds.

There is an abundance of literature on the use of compost and compost tea in the landscape, must more than we can cover here. However, in our step by step, we will give you ideas for using compost to regenerate your soil.

Mulch

Mulch is another primary component of our organic system for soil regeneration. We advocate keeping all your soil covered at all times. Whether it is green mulch in the form of growing plants or brown mulch in the form of straw, wood chips, or some other organic material, the importance of mulching

your soil cannot be underestimated. Keep that soil covered to protect it from harsh sunlight, to moderate soil temperatures and to help retain valuable soil moisture.

Worm Castings

Worm casting is commercially available and is an invaluable source of nutrients for your soil. They provide a rich source of food for other soil organisms, plus most worm castings include a large number of worm cases, the containers for worm eggs. When these worm cases are incorporated into the soil, they hatch and can give your soil a jump start in building a rich and diverse soil biome.

Molasses

I get a lot of strange looks when I suggest that molasses are a key ingredient in soil regeneration. Many of the organisms that we are encouraging in our soil need carbohydrates, sugars, to thrive and multiply. Adding molasses to the soil in the form of a liquid spray or as a dry granular product is a great way to jump-start the growth of bacteria and fungi in the soil.

The preferred product in liquid form is blackstrap molasses that is unsulphured. This can be found in many grocery stores or at feed stores in large bulk quantities. Dry molasses is a granular product made by soaking the cornmeal in molasses and then drying it. It can be broadcast or incorporated into compost tea.

Rock Minerals

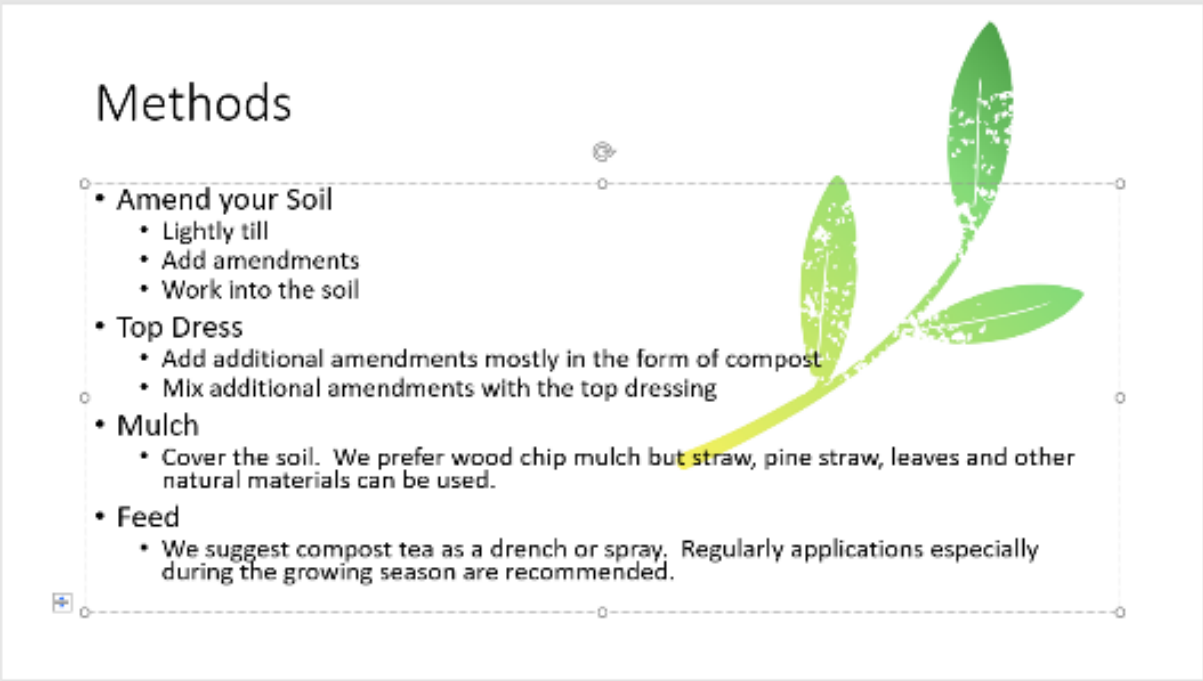
Rock minerals are different materials, all coming from nature. Such versions and Texas Green Sand, lava dust, rock phosphate, and decomposed granite are easily funded at most good garden suppliers. These products bring the trace minerals to your soil as well as help to add structure and tilth.

Coffee Grounds

Many people overlook the value of coffee grounds in the garden and landscape. Coffee grounds are rich in trace minerals and offer an excellent source of organic material. They can be used in several ways on turf, in the vegetable garden, and around ornamentals. From a soil health perspective, earthworms love coffee grounds and a sure way to attract them to your garden.

Carbon (biochar)

If your site has been contaminated by the recent use of toxic chemicals, adding carbon can be an effective way of remediating the residual effects of these compounds. Carbon is known for its affinity for trapping and holding a wide number of toxic compounds and heavy metals.



Methods

TO get started building healthy soil, I am going to make some recommendations, and the first one is going to contradict an earlier statement. To begin the regeneration process of your soil, you must amend the soil and return some vital nutrients and materials to the soil. The easiest and quickest way to do this is as follows.

- Lightly till your soil.
    - This is contradictory, but there is a logic behind the contradiction. If your soil is already damaged and devoid of subsoil life, you are going to do very little further damage by tilling the top two or three inches. I don't advocate deep tilling, only a light surface till to loosen the compacted and crusted soil.
- Add your Amendments
    - To regenerate garden soil, we suggest adding the following to your soil.
        - Compost at a rate of 4 to 6 inches over the entire area
        - Rock minerals at 10lbs per 100 sq feet
        - Worm Castings at 5 lbs per 100 sq feet
        - Dry Molasses at 5 lbs per 100 sq feet
    - Mix these ingredients and spread evenly over the ground you have lightly tilled and then tell again to incorporate the amendments into the top layer of garden soil. Don't over till and don't try to till wet ground.

    - Mulch. Cover your exposed freshly amended soil to protect the soil from sunlight, wind, and to maintain the soil moisture.
- Turf and Perennial Beds
    - Mix compost and other amendments as directed above and top dress your soil around your perennials to a depth of two or three inches and add a generous layer of mulch over the topdressing.
    - Turf should be top-dressed twice a year with one half to one inch of high-quality compost. The compost can be missed with the amendments listed above. It is not necessary to water in the compost. It may look unsightly at first but will quickly incorporate into the soil and disappear from the turf.
- Mulch
    - Mulch everything, especially bare soil.
    - Wood chips are preferable. If you can source locally that is even better. Avoid bark cypress and any of the dyed colored mulch materials. Straw will also work as well as leaves and grass clippings.
- Feed Regularly
    - We recommend feeding with compost tea every two weeks during growing season and at least once a month in the winter months. Compost tea is easily made at home, and there are complete instructions on our website. Amendments such as worm castings and molasses can be added to your compost tea to supercharge its effects.

Links and Resources

For more information about organic gardening, lifestyles, and living, visit our website at West Texas Organic Gardening.

If you found the information here helpful, you might also find these articles on our website of interest.

Organic Growing Myths

Toss Your Tiller

Mulch

If you have more specific questions or problems, you can contact us using the contact form on our website. You can also post your question to our community forum at this page; West Texas Organic Gardening Community Forum.

We have a Facebook page and love your comments, questions, or input. You can find us on Facebook using this tag. @westtexasorganicgardening