

SOIL & CARBON

SOIL SOLUTIONS
TO CLIMATE PROBLEMS



CENTER FOR
FOOD SAFETY

2015

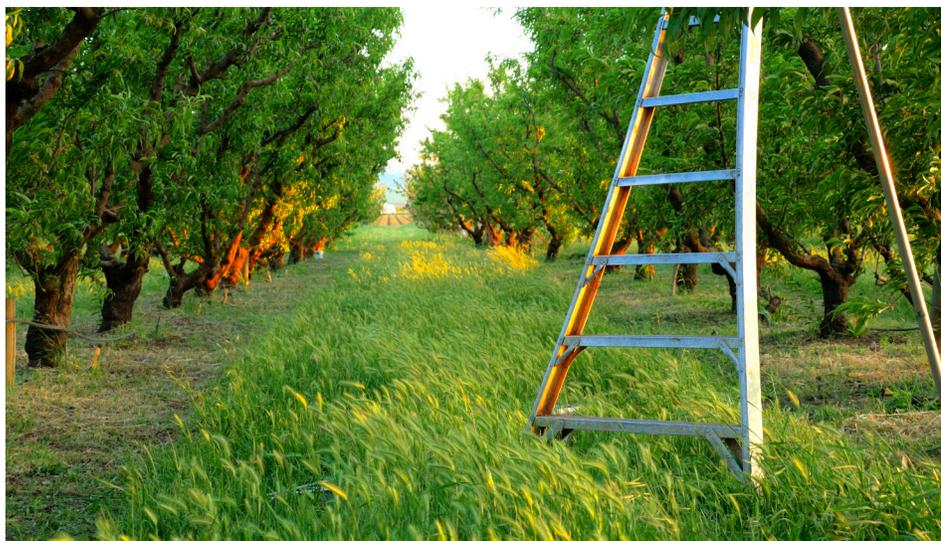
While the farmer holds the title to the land, actually it belongs to all the people because civilization itself rests upon the soil.

- Thomas Jefferson

AN OVERVIEW

An excess of carbon dioxide (CO₂) in the Earth's atmosphere is warming the planet and increasing the severity and intensity of extreme weather events. Because the atmosphere can only absorb so much of this greenhouse gas, excess CO₂ is dissolving into our oceans, causing them to acidify. Ocean acidification not only harms marine life, it puts food webs at risk.¹

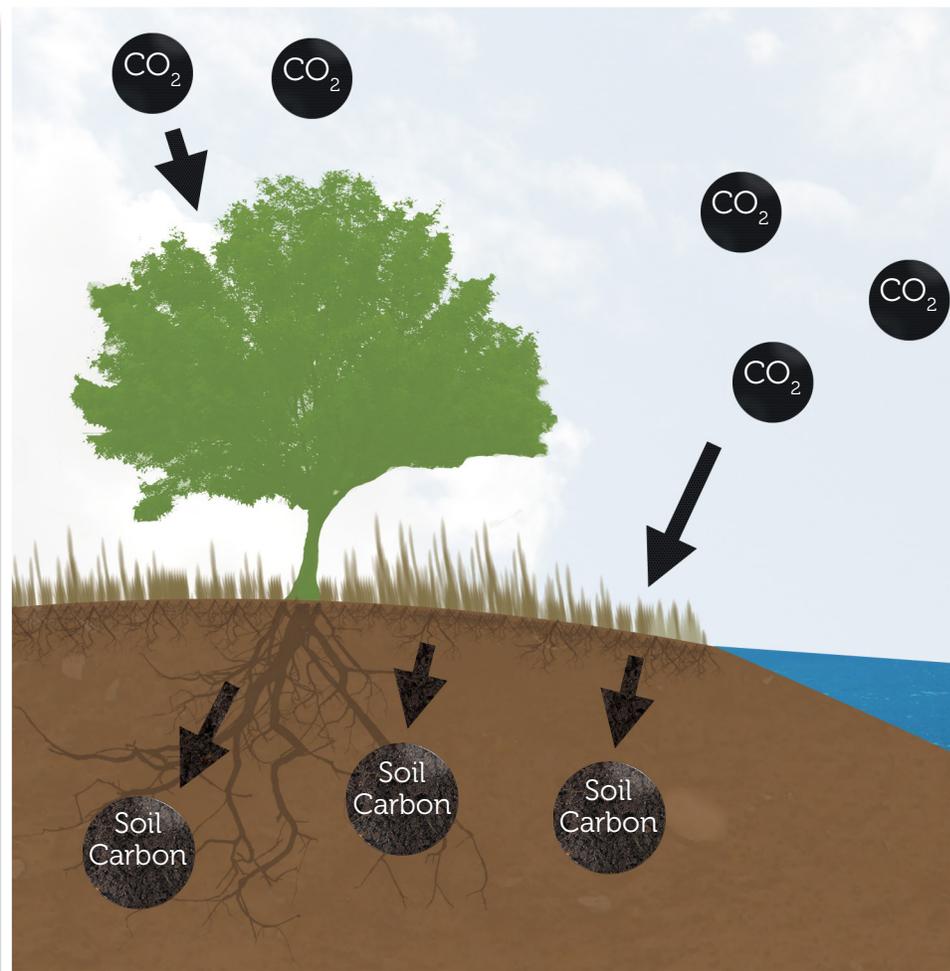
While this is a grim state of affairs, there is hope, and it is right under our feet in the soil. In fact, soil is the largest “sink”—or area of storage—where additional carbon would actually be extremely beneficial. Currently our cultivated soils globally have lost 50-70 percent of their original carbon content.² This means we have a tremendous opportunity to put carbon back into the soil where it creates positive feedback loops, making healthy soil a systemic solution to multiple problems including food and water security. Not only is rebuilding soil carbon entirely possible, unlike drastic climate mitigation measures like geoengineering, it is without risk.



HOW DID CARBON BECOME A PROBLEM?

A key element of all living things, carbon is constantly cycling through different spheres as either a liquid, solid, or gas. Human activities—including the burning of fossil fuels, deforestation, the draining of wetlands, and repeated tillage—have disrupted the carbon cycle, taking it out of balance. Carbon per se is not the problem as there is a fixed amount of carbon on the planet. Humans are altering the chemistry of where carbon is stored, and climate change is a manifestation of that alteration.

Another way of looking at the problem is that too much of the carbon that was once in a solid phase in the soil is now a gas.³ As a result, there is too much carbon in the atmosphere, too much in the ocean, but not enough stable carbon where it once was, in the soil.*



The process that actually removes CO₂ from atmospheric circulation is photosynthesis.

- Christine Jones, Soil Ecologist

HOW DOES ATMOSPHERIC CARBON BECOME SOIL CARBON?

The Earth's soils store 2,500 billion tons of carbon—more carbon than the atmosphere (780 billion tons) and plants (560 billion tons) combined.⁴ Additionally, fossil fuels, formed from ancient, fossilized plants and animals, store another 5,000-10,000 billion tons of carbon.⁵ When burned, carbon molecules combine with two oxygen atoms to form CO₂, a gas.

*In fact, from 1750 to 2011, about one-third of total human-caused emissions were released through deforestation and land use change⁶ (approximately 43 percent of which came directly from the Earth's soils).⁷

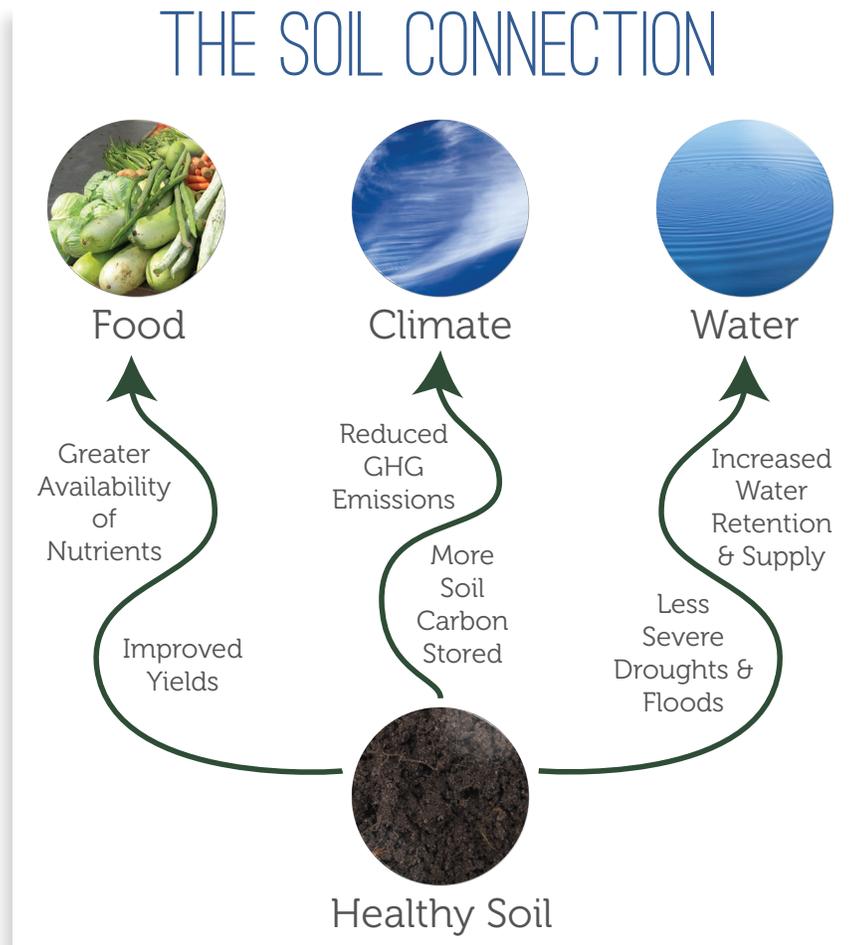
Plant photosynthesis has the remarkable ability to capture atmospheric CO₂, release the oxygen back into the atmosphere, and convert the carbon into sugars. The plant uses some of this to produce above ground growth such as leaves. Meanwhile, as much as 40 percent of the captured CO₂ is released through the plant's roots to feed soil microbes, which in turn assist the plant in acquiring nutrients.⁸ Microbes rely on this energy to create complex, stable forms of soil carbon, including humus.⁹ If left undisturbed, soil humus can lock carbon into place for "an average life-time of hundreds to thousands of years."¹⁰

We know more about the movement of celestial bodies than about the soil underfoot.

- Leonardo da Vinci

WHAT IS THE CONNECTION BETWEEN SOIL CARBON AND FRESH WATER STORAGE?

Healthy soils have aggregates, structures that create air pockets, allowing water to infiltrate the soil profile. Healthy soils act as giant moisture holding sponges, a function that is especially important in times of drought and flooding. When the aggregates are missing, soils lack pore space and can become easily compacted. Compacted soils lose the ability to absorb water, resulting in erosion and sometimes flooding. In order for rainfall to be effective, it must be absorbed by the ground where it falls. To do this the soil must have carbon to build aggregates.



HOW DO SOILS LOSE CARBON?

Fertile soil can be degraded and lose carbon in a variety of ways. Paving over land kills soil microorganisms, rendering soil lifeless and interfering with natural carbon exchanges. Soils also lose carbon when native grasslands are converted to cropland. In the United States, for instance, between 2008 and 2012, 1.6 million acres of long-term grasslands were converted to cropland, releasing an equivalent amount of carbon to that of 28 million cars on the road or 34 coal-fired power plants.¹¹ As the United Nations Convention to Combat Desertification explains, “carbon is then trapped in the air as carbon dioxide, with nowhere to go, because degraded land loses its ability to capture carbon back into the soil. In this way, land degradation fuels climate change.”¹²

*The soil is the
great connector
of our lives,
the source and
destination of all.*

- Wendell Berry

Soils also lose carbon in less obvious ways including: the long-term use of extractive farming practices such as tillage, leaving soils uncovered and exposed to the elements, and failing to feed microorganisms with organic matter. According to Ray Archuleta, an agronomist with the Natural Resources Conservation Service (NRCS), “our soils are naked, hungry, thirsty and running a fever.”



HOW CAN WE REBUILD SOIL CARBON?

Because fertile soil is alive and teeming with living organisms, it needs to be fed organic matter. In fact, the abundance of soil microbes and other organisms is generally proportional to the soil's organic matter content.¹³ It is important to feed soil and protect it from temperature extremes, as well as from wind and water erosion, by keeping it covered. This can be done on agricultural lands by keeping the ground protected with a mix of cover crops (living plant roots feed soil life below), by leaving crop residues, and by using proper pasture management.

We can rebuild soil by adopting regenerative, organic agriculture including: polyculture, cover cropping, agroforestry, nutrient recycling, crop rotation, and organic soil amendments like compost and biochar.

*The real Arsenal
of Democracy is
a fertile soil, the
fresh produce
of which is the
birthright of
nations.*

- Sir Albert
Howard



WHY IS REBUILDING SOIL CARBON ESSENTIAL?

Rebuilding soil organic matter on a global scale is essential for food, water, and climate security. The multiple benefits of healthy soil are incalculable for: improved crop yields; a greater availability and variety of nutrients in food; increased retention and supply of fresh water; and, as more carbon is stored in soil, reduced greenhouse gases in the atmosphere. Soil erosion is an issue of global concern and widespread disregard for soil as the basis of our food system has led to desertification, hunger, and climate instability. Conversely, rebuilding soil health by increasing its carbon content will make communities more resilient in the face of escalating climate-related challenges.

WHAT IS THE OPPORTUNITY?

Scientists are just learning about soil's sequestration's capacity, and as a result estimates vary on exactly how much carbon we can store. Rattan Lal, director of Ohio State University's Carbon Management and Sequestration Center and president elect of International Union of Soil Sciences, estimates that with proper management, 75-100 parts per million of CO₂ could be stored in soil and forestry systems.¹⁴ Others believe the potential may be higher. Regardless of the actual amount, two things are certain: we have a global soil carbon deficit that can be addressed immediately by transferring atmospheric CO₂ into soil humus through plant biomass, and we know restoring soil health is the only way we can provide enough food and water to everyone on the planet.

WHAT ARE THE RISKS?

Unlike geoengineering, rebuilding soil carbon is a zero-risk, low-cost proposition. It has universal application, and we already know how to do it. All that stands in our way is a greater awareness of the opportunity and the political will to make it happen.

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*Soil truly is
the skin of
the earth—the
frontier between
geology and
biology.*

– Professor David
R. Montgomery



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CARBON-RICH SOIL COURTESY OF SINGING FROGS FARMS



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