The Good Earth Carbon and Agriculture

By Robert Sirrine
Photo by Carole Topalian

Carbon. It's a short word—only six letters. The chemical notation gets even shorter—C. But its diminutive length as a word belies its importance for life on earth. Carbon is the building block of life, the majority element in every living thing, and the basis of photosynthesis. As if following a recipe from the Food Network, plants take up carbon dioxide (CO_2) from the air, add a dash of sunshine and—BAM!—carbon is converted into glucose, the main ingredient in plant tissue, plus a nice byproduct for us animals: oxygen. When those plants die, their tissue is decomposed by living microbes, releasing some CO_2 back into the air, but also forming soil organic matter, a.k.a. SOM to agronomists and Black Gold to farmers. Over thousands of years, this is the very process that formed the deepest, richest soils in the world, the soils that supported the prairies of the Great Plains. Walt Whitman suggested, "… while I know the standard claim is that Yosemite, Niagara Falls, the Upper Yellowstone and the like, afford the greatest natural shows, I am not so sure but the Prairies and Plains, while less stunning at first sight, last longer, fill the esthetic sense fuller, precede all the rest, and make North America's characteristic landscape."

Back to carbon. Wes Jackson, an agricultural visionary who spoke last year to a packed State Theatre in downtown Traverse City, contends that there are five pools of energy-rich carbon that stand behind human civilization. The first, since the beginning of agriculture 11,000–13,000 years ago, is the soil. Next, the carbon from the forests that provided the energy for the Bronze and Iron Ages. Then came coal, which fueled the Industrial Revolution. Today's C-rich energy source of choice represents the fourth and fifth pools: oil and natural gas. No matter the source—soil or oil—the first law of thermodynamics requires that energy cannot be created or destroyed. The carbon we use has to go somewhere. Whether by discing the soil, or burning

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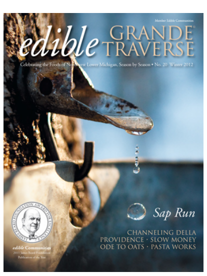

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carbon in the form of trees, coal, oil, or natural gas, C is released into our atmosphere as CO_2. The CO_2 concentration in the atmosphere today has risen to around 385ppm, which is 30 percent higher than it has been in the last 800,000 years.

Houston, We Have a Problem

The first pool of carbon was the soil. Why does this matter? One conclusion of the Millennium Ecosystem Assessment[1] is that, "Agriculture is the largest threat to biodiversity and ecosystem function of any single human activity." Thus we have come to what Wes Jackson contends is the "problem of agriculture."

There is irrefutable evidence that excessive tillage, deforestation and overuse of agricultural chemicals have resulted in soil erosion, loss of biodiversity and thousands of dead zones in our lakes and oceans, respectively. The soil that underlies the great prairies that Whitman spoke of developed over millennia; but in short order, the carbon content of these soils, the same carbon contained in soil organic matter, which has contributed to the best crop yields in the world, has decreased 50–90 percent since agriculture began in the United States. It takes from 200 to 1000 years to form one inch of topsoil on land that is being cropped. The U.S.A. and Europe have the lowest soil erosion rates in the world; still, 17 times more soil is lost than is created each year. This translates to two tons of SOM/hectare/year.

How did this happen? Prior to the end of WWII, legume-based rotations were common, providing soil nitrogen for the production needs of the time. These biologically based systems fell out of favor as chemical companies, stuck with excess nitrogen inventory after the war, looked for a new market. The Dows and Duponts of the world converted to production of nitrogen-based agrichemicals to supply

U.S. farmers. The shift from legume- and manure-based fertility to chemical fertility inputs was rapid, and over time, with increasingly heavy crop loads to boot, less and less plant material was being returned to the soil. Researchers from the University of Illinois, using data from America's oldest experimental field, established in 1876, recently noted that 40–50 years of inorganic

nitrogen destroyed soil quality over time. They conclude that "the scientific basis for input-intensive cereal production is seriously flawed."

So, how does depletion of soil carbon result in losses in agricultural productivity? As plants break down and are decomposed by microbes, the carbon they are made of is converted to soil organic matter. This SOM plays a crucial function in maintaining soil structure and stability, increasing water infiltration and plant-available water capacity, and facilitating nutrient availability for plant uptake. SOM is the most important physical, biological and chemical indicator of soil quality. It is the foundation for all plant growth.

[1]*Published in 2005, and prepared by 1360 of the world's leading scientists, the MEA provides a scientific appraisal of the state of the world's ecosystems, the services they provide, and the scientific justification for their conservation.*

Diminishing Returns

Our current model of industrial agriculture is built upon a house of carbon cards in the form of cheap petroleum. Northwestern Michigan farmer Marty Heller conducted a life cycle-based assessment of the U.S. food system as part of his postdoctoral work in chemical engineering and found that 40 percent of the energy used in agriculture is used to produce fertilizers and chemicals. With all of the energy going into producing food, and the massive amount of subsidy dollars going to support this system of production, you would think that we'd be getting a big bang for our buck. Wrong. Researchers have calculated that, while use of nitrogen globally has increased from 10 million metric tons in 1960 to 100 million metric tons in 2005, the efficiency of its use has decreased from 80 to 30 percent. Even while nitrogen use in the United States has leveled off, mostly as a result of no-till farming practices, its use in developing countries like China has increased dramatically.

In 1940, for every calorie of fossil fuel energy spent, farmers produced 2.3 calories of food energy. A 2002 Johns Hopkins study shows that the ratio has more than flipped on its head—now it takes three calories of fossil energy to produce one food calorie. Add processing and transportation and the ratio becomes 10 to 1. The vast majority of carbon spent today is used to produce meat: Over three quarters of the grain that is grown is fed to animals. It takes 35 and 68 calories to produce one calorie of beef and pork, respectively. In essence, the Big Macs we eat are concentrated oil. Farm systems of the past relied on legumes and crop rotation, and animals played a vital role in this complex system—they grazed the pastures and their manure was spread back on the land to replenish the soils. Today, because of consolidation of livestock operations, animal waste is produced in such vast and concentrated quantities that it qualifies as toxic waste. In essence, you and I, through taxpayer subsidies, are sacrificing sustainability for short-term economic gain. With an ever-increasing human population, decreasing supplies of fossil fuel carbon, and the concomitant and inevitable increasing costs to produce food, what does the future hold?

Looking Ahead

Before I am taken for one who recommends returning to the bucolic days of old, let me say that such a return is not wholly possible, nor would it begin to solve the problem of agriculture. Still, with an increasingly inefficient industrial agriculture model that destroys the soil carbon needed to sustain crop yields, something must be done. Burying our heads in the proverbial sand will not topple agriculture from its unenviable throne as the greatest threat to biodiversity and ecosystem function. However, to get back to the first pool of exploited carbon, the soil, may provide us with a path back to safety.

Wes Jackson, Wendell Berry and Fred Kirschenman—three elder statesmen of the new agricultural movements—cite that there is a need to "perennialize the American farmscape." They advocate using the current five-year farm bills as stepping stones toward a 50-year farm bill. Through development of perennial grains, that have soil-binding roots reminiscent of the Great Plains of the past, they envision an agriculture that "reduces soil erosion, eliminates toxic chemicals, manages nitrogen, reduces dead zones and restores the agrarian way of life." In this way, instead of destroying soil quality over time, modern agriculture can convert from being a major source of CO_2, to become an even greater carbon repository.

Conserving soil carbon through management is the key. Perennializing America's farmscape, setting aside less productive land, practicing crop rotation, no-till, and planting cover crops will conserve soil carbon. In *The Principles of Agriculture,* published in 1904, authors Goff and Mayne suggested: "The farmer should frequently grow clover, or some other nitrogen-gathering crop, on his land. Land from which a crop is harvested at midsummer, and which will not be needed until the following spring, may often better be sown to clover than left idle. As a rule, the farmers that grow and feed the most clover have the most fertile farms. The clover plant should be regarded as a symbol of good luck to the farmer, whether it has three leaves or four."

Only 75 years ago, the Roosevelt administration created the Soil Conservation Service to alleviate the effects of the Dust Bowl. The gravity of the situation hit home in late 1933, when the skies over Washington D.C. were darkened by soil from the Plains States, blown down what is now the I-80 corridor. The challenge today is more complicated and, many would argue, more severe. Not only are we depleting soil organic carbon, but also petroleum carbon, in a way that is warming the planet. U.S. farm and grazing land currently stores around 20 million metric tons of carbon. Researchers at the USDA Agriculture Research Service contend that with improved management and proper soil conservation there is the potential to store 200 million metric tons.

The problem of agriculture is inherently linked to carbon. And carbon, like agriculture, permeates ecology, politics, economics and thus society as a whole. It is a multifaceted issue requiring a multifaceted approach. Farmers, not a group to sit idly by, can help by undertaking practices that build and conserve soil carbon. You and I can lessen our own carbon footprint by purchasing food grown and processed with the fewest energy inputs. For starters, food produced here, closer to home. We all have a role to play if we are to leave the world a better place for our children's children. Jared Diamond, in his book *Collapse: How Societies Choose to Fail or Succeed,* warns of the consequences if we choose not to act: The Greenland Norse, the residents of Easter Island, the Anasazi of the American Southwest, the Mayans, and more, all collapsed due to environmental degradation. Today's society faces additional concerns such as human-caused climate change and energy shortages. No doubt there are those who say this view is sensationally fatalistic. But if the ghosts of great civilizations past could offer us any advice, surely it would be to gather and conserve the soil carbon that nurtures, and conserves, us all.

Dr. Robert Sirrine is a Community Food Systems Educator with Michigan State University Extension in Leelanau County.

info@ediblegrandetraverse.com • P.O. Box 930 • Traverse City, MI 49685

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