CARBON SEQUESTRATION, NATURALLY

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It is time for the conversation about climate change to shift from problems to solutions. For too long we have learned how serious this problem is, how it contributes to the loss of biodiversity or even, some assert, to the extinction of human life on earth. The net result of this focus on the problem of climate change is that people have become hopeless and fatalistic while carbon emissions continue to rise. Many people can recognize the scientific truth about climate change on an intellectual level and still deny it on an emotional level because it is too overwhelming. Such split consciousness leads to paralysis.

The solution to climate change is to reduce carbon emissions and to get the excess carbon dioxide out of the air. Part of this task is political; we need policies, such as a tax on carbon, that could curtail the burning of fossil fuels, which probably causes most of global warming. Even this is daunting at a time when large energy corporations seem to control policies. But much carbon dioxide also escaped from the soil because of deforestation and agricultural practices. Can this carbon dioxide be sequestered back into the soil and stored in plants? This is the question explored in this paper.

It is possible to sequester carbon in natural ways that are beneficial to life on the planet. Once we learn this we can move from hopelessness to hopefulness. This is especially true if many of us can actually participate in solutions to global warming. Rising prices for energy and food are already

pressuring social changes as new attitudes about food raising emerge. Unused land in many cities opens possibilities for urban gardening, and rising unemployment opens the need and time to do so. Also evident is new interest in a back-to-the-land movement motivated by rising food prices. In view of such trends, this paper disagrees with many writers about climate change who simply assume that our future will be shaped by business as usual with increasing emissions of carbon dioxide.

It will be helpful, as we look at ways to sequester carbon dioxide, to have a clear understanding of how it is emitted. The burning of fossil fuels has already been mentioned, and it is certainly a major factor. Deforestation is also mentioned as a cause of global warming along with agricultural practices such as tillage. The amounts here are much more difficult to quantify than carbon emissions from burning fossil fuels, and where hard data is not available some scientific writers seem to avoid the issue. This would be a serious error, because if we fail to see that carbon is in soil, how it escaped from the soil, and how it could be sequestered back into the soil, we miss an important opportunity.

The Value of Organic Farming

Carbon exists in the soil as organic matter. When tillage exposes it to air it oxidizes and escapes as carbon dioxide. The pioneers plowed the prairie of perennial grass to plant the annual grasses we know as grains, such as wheat or corn. These are great for food production because annuals put their energy into seeds instead of into roots as perennials do. Those pioneers were part of a process, begun with the origins of plowing hundreds of years ago, in which large amounts of carbon dioxide escaped as the prairie lost its organic matter and fertility. We speak of this process as the

loss of topsoil, and water and wind erosion contributed to it, but it is more specifically the loss of organic matter that destroyed soil fertility.

This early agricultural regime was clearly not sustainable and it soon had to be subsidized with chemical fertilizers, especially for nitrogen. This was made available after World War II with anhydrous ammonia, after it was no longer used to manufacture explosives. The fertile soil that was lost through bad agricultural practices was now replaced by chemical fertilizers. These could make plants grow but they also destroyed much of the biological life that had earlier liberated nutrients for plants. The result was the release of more carbon dioxide and methane. Other fertilizers, treated with acid to make them water soluble, were soon added to supply plants with phosphorus and potassium, and they added to the destruction of earthworms and other microbial life in the soil.

These so-called artificial or chemical fertilizers produced plants that were more vulnerable to insect pests. Monocultures, large fields of the same crop, added to this vulnerability. This led to the "need" for pesticides which, when dumped on farmland, continued to kill off any remaining micro-organisms in the soil. Organically-grown plants are less attractive to insects and organic growers do not use chemical pesticides. When they notice damage from insects they seek to understand why and employ more knowledge-intensive management strategies. Organic farmers and soil scientists have long criticized chemical farming for destroying life in the soil and they have evolved the adage: "feed the soil, not the plant." Organic farming is so called because it seeks to maximize organic matter (i. e., carbon) in the soil.

This happens naturally in photosynthesis as solar power uses carbon dioxide in the air to make plants grow and provides oxygen in the process. As the plants decompose and their organic matter is worked into the soil, carbon is sequestered. But this requires a living soil, in which the soil micro-organisms and larger organisms, such as earthworms, have not been damaged by chemicals.

Most of the details in the preceding paragraphs were based on my many years of experience as a part-time organic farmer who was also an Environmental Studies professor trying to understand what he was doing. The emphasis on organic matter in the soil (carbon), and its loss after hundreds of years of plowing, has also been reviewed by Albert Bates in *The Biochar Revolution: Carbon Farming and Climate Change*. He reports that soil scientist Rattan Lal at Ohio State University found that, with better carbon management practices, soils in the continental US could soak up 330 million tons of carbon each year, more than the emissions from cars, and improve food production by 12%.

Several books on the details of carbon offsets have been published recently. One that supports carbon sequestration in soils and forests is *Harnessing Farms and Forests in the Low-Carbon Economy: How to Create, Measure, and Verify Greenhouse Gas Offsets* and it was edited by Zach Willey and Bill Chameides. This book was intended to help those whose business causes carbon emissions to purchase carbon credits or offsets from land owners who can sequester carbon. Some trading like this already happens in other countries. If a "cap and trade" program is mandated in this country a book like this will be indispensable.

Specific programs to increase the amount of carbon stored in soil include better tillage methods which avoid plowing, increasing carbon inputs from crop residue, switching from annual crops to perennial plants, and reducing the use of nitrogen fertilizer. Programs to increase the amount of carbon stored in trees, which are said to be the most common and most productive, include establishing new trees, allowing existing trees to grow larger, increasing the carbon in wood products, and decreasing the loss of carbon stored in trees (pp. 22-35). All these programs reinforce the idea that carbon can be sequestered in soil and plants, and although they are not explicitly promoting organic farming, some of the programs would implicitly support organic methods.

A paradigm shift to organic farming is needed in agricultural science. But although the United States Department of Agriculture tolerates organic farming, and regulates organic produce, neither it nor state agricultural schools and their extension services have given up the chemical paradigm of conventional agriculture. Given the political power of agroindustrial corporations, this is not likely to happen soon, but it is beginning. Michigan State University scientists at the Long Term Ecological Research site at the Kellogg Biological Station found that conventional row crop farming emitted about as much carbon dioxide as organic row crop farming sequestered, while unmanaged ecosystems on abandoned farmland in the early stages of succession toward trees sequestered about four times more carbon dioxide than organic farming. This could lend support to tree crops for carbon sequestration.

The Needed Transition to Tree Crops

Wes Jackson, who is developing perennial prairie plants to produce grains at the Land Institute in Kansas, has argued that the best agriculture

in any region is the one that best mimics the region's natural ecosystems. In the eastern part of the United States this would be forests of various kinds, and my local Conservation District, in urging people to plant more trees, claimed that an acre of trees removes 2.6 tons of carbon dioxide each year from the air. These trees can be food producing, as J. Russell Smith explained in his important book of 1929, *Tree Crops: A Permanent Agriculture.* Smith's book was largely ignored for nearly fifty years until his argument was resurrected in new ways by Bill Mollison and David Holmgren as permaculture. This is now a rapidly growing movement which, although it had been focused on household food production, is now expanding beyond that. A new book by Mark Shepherd called "*Restoration Agriculture: Real World Permaculture for Farmers,*" demonstrates a larger project of tree crops on his 106 acre farm in Wisconsin. Permaculture generally emphasizes the revitalization of life in the soil and by building organic matter.

The new argument for tree crops is emerging in the context of a changing climate. As they replace the energy-intensive annual food crops, tree crops, with their deeper roots, can withstand droughts and violent rainstorms which would otherwise cause loss of organic matter from soil. They can slow the process of climate change as they store more carbon, and thrive with virtually no tillage. In the longer term, when trees mature and need replacement, they can be burned with limited oxygen (pyrolysis) and turned into charcoal, so-called biochar, and worked into soil for permanent sequestration. I have patches of dark soil on my farm where fruit trees were gathered and burned years ago and they remain more fertile.

Carbon sequestration in biochar or in tree crops is largely ignored by scientists who seek one total technological solution to climate change. This is easily seen by googling "carbon sequestration." Many large scale,

expensive, and risky geoengineering projects have been proposed; some may eventually be necessary if we continue to ignore the many small-scale and natural possibilities that are available.

Meanwhile, those sequestration strategies that are beneficial, safe, and natural are ignored because they might not do the job by themselves. We must insist that better farming methods and more tree crops should be promoted to sequester carbon dioxide and used as other safe and cost effective methods evolve. It would be foolish to sequester carbon in ways that do not simultaneously improve the soil. And we need to be open to the social changes that are serendipitously pressured by higher energy prices and thus slow emissions: more local food systems, more small farms and homesteads, more people active in Transition Towns, and more tree planting which gives people a stake in the fight against climate change. Here it is the people who will lead in the changes that are necessary. They should be helped with appropriate governmental policies and assistance.