From the Ground Up

Carbon Sequestration and Healthy Soils Are Good for the Air

Agricultural lands can play a role in offsetting greenhouse gasses by storing carbon in soil.

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Knowledge to Go Places

Keith Paustian's research has him covering a lot of ground. In the space of two weeks, Paustian, professor of soil science at Colorado State University, is speaking at conferences in the United States, Canada, and Central America. He is describing carbon sequestration, the buildup of the stock of carbon in organic matter in soils. Paustian is concerned with measuring how soil carbon is affected by land management and other environmental factors. His work contributes to guidelines that can help produce healthier soils and cleaner air.

Carbon dioxide (CO_2) is the most abundant of the greenhouse gases, and its level in the atmosphere has risen from a pre-industrial level of 280 parts per million to current levels of 395 parts per million. However, carbon dioxide is also necessary for plant life. It is taken up by plants through photosynthesis. When plants die, the carbon goes into the soil as organic matter. It is stored in the soil until the organic matter is broken down by microorganisms. As the microorganisms respire, carbon dioxide returns to the atmosphere.

In 2002, the United States Environmental Protection Agency claimed that CO_2 was the largest source of U.S. greenhouse gas emissions, accounting for approximately 80 percent of global warming potential weighted emissions. Most of the carbon is put into the atmosphere by burning fossil fuels. Agriculture is only responsible for a small portion of the carbon put into the atmosphere, but agricultural lands can play a significant role in temporarily offsetting greenhouse gas emissions by storing carbon in soil.

"The time during which carbon is stored in soil can vary from a few weeks to thousands of years," says Paustian. The chemical makeup of the soil, the variety of the plant material, climate, and land management can all contribute to how quickly carbon dioxide returns to the atmosphere. Carbon can't be held in the soil indefinitely. Soil sequestration is not a permanent solution to the carbon dioxide problem. "Soil is a holding tank," Paustian stresses, "but the size of the holding tank can be increased through certain land management practices."

Farmers can increase the amount of carbon going into soil by cultivating plants that have greater biomass and by planting cover crops. To slow the process by which carbon leaves the soil, they can seek out plants that have chemical components like high lignin and tannin contents that reduce decomposition rates.

Conservation tillage is another way that farmers can increase the store of carbon in soils. When soil is physically disturbed or mixed by tillage, the activity of microorganisms tends to increase, accelerating the return of carbon dioxide to the air. Conservation tillage is a broad term for a variety of farming methods aimed at reducing the intensity of soil tillage. Taken to the fullest extent, conservation tillage can mean no-till, a planting process that involves no plowing whatsoever.

In some cases, land managers may even choose to convert less profitable (and often highly erodible) croplands to growing trees or grasses. "Perennial grasses have a lot of biomass going into root development, which puts more carbon into soils," Paustian says.

More than a hundred years ago, when large-scale agriculture was introduced to the native prairie, soils in the United States began to lose large amounts of organic matter. "Soils were mined out, plowed, disturbed," Paustian explains. "Most cultivated soils have about half the organic matter they had originally, but in general, we are managing our soils much better than we have in the past."

One of the challenges that Paustian faces in developing carbon dioxide mitigation programs is the variability in the way that soils store carbon. Areas where rainfall is abundant and temperatures are moderate tend to accumulate carbon most rapidly. But the high land prices and the net returns per acre of these lands, which often are also very favorable for traditional agriculture production, mean that higher incentives may be needed to change to land management practices that foster carbon sequestration. Similarly, irrigated land can produce greater plant biomass, which adds large amounts of organic matter to the soil, but the power required for pumping irrigation wells and the fertilizers added to crops, which can increase amounts of the greenhouse gas nitrous oxide (N_2O), may cancel out any positive impacts on carbon dioxide emissions. Recommended carbon dioxide mitigation programs must benefit the whole environment.

However, many farmers currently are using improved land management practices that promote carbon sequestration without receiving any direct monetary incentives. "Many of these practices just make farmers more competitive and pay for themselves over time," Paustian notes.

In some ways, the manner in which farmers have gone about adopting practices that enhance carbon sequestration in soils mirrors Paustian's own development as a scientist. "I was always interested in understanding what farmers need to know to keep soils healthy," claims Paustian. "It's just coincidental that practices that foster carbon sequestration and healthy soils are also good for the air."

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Hitting the Ground Running

The United States Department of Agriculture estimates that the nation's cropland can sequester about 75-200 million metric tons of atmospheric carbon per year if current best management practices are implemented.

In 2002, the White House announced a plan to reduce the growth of United States greenhouse gas emissions. Part of the plan involves developing incentives for farm and forestland owners and managers to voluntarily adopt land uses and management practices that sequester carbon.

Managing lands to increase carbon storage can only temporarily offset greenhouse gas emissions, but it is possible that the advantages gained by implementing these land management practices can buy time to address the problem of reducing greenhouse gas emissions.