GRACEnet A Unified Response to Climate Change

Most of the greenhouse gases believed to be warming the planet come from the burning of fossil fuels, but agriculture can play an important role in mitigating those emissions.

Green plants capture carbon dioxide through photosynthesis and store carbon in their tissues. Soil stores organic carbon, but can emit methane and nitrous oxide. The amount of carbon stored and gas released depends on how and whether the land is tilled, the amount of crop residue left in the field, soil moisture, application and form of fertilizer, and type of crops planted.

ARS scientists are looking for ways that agriculture can help reduce greenhouse gases through improved tillage and fertilizer use and cropping systems that sequester more carbon in the soil and keep it out of the atmosphere.

The concept behind GRACEnet (Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network) is simple. Scientists are comparing traditional systems with alternatives, using regional approaches and the same protocols to test soils, measure plant growth, and keep track of weather conditions and greenhouse gas releases. GRACEnet researchers are spread out over 32 sites across the country, but they communicate often and meet periodically. They work towards four goals: a national database on greenhouse gas flux and soil carbon storage; regional and national guidelines; upgraded computer models to estimate the effects of cropping systems and other crop management practices on net greenhouse gas emissions; and scientific papers to guide federal and state policymakers.

The overall goal of the 5-year project is to develop strategies and tools that producers can use to reduce agriculture's climate-change footprint, says Ronald Follett, GRACEnet lead scientist and a senior supervisory scientist at the ARS Soil Plant Nutrient Research Unit in Fort Collins, Colorado.

Regional approaches are necessary because the factors that determine how much greenhouse gas is released—such as soil quality, types of crops raised, rainfall patterns, and temperature ranges—vary tremendously from one location or region to the next. Besides, those scientists best equipped to come up with alternatives for farmers are the ARS researchers who work closely with them, according to Follett.

"The scientists at each site are in touch with producers and local farmers, so they're familiar with local issues affecting them," he says.

Lessening the Effect of Biofuel Crops

As part of his contribution to GRACEnet, Follett and his collaborators are studying the effects of raising corn for biofuels on a Nebraska field where bromegrass had previously been growing for 13 years. Planting grass became popular in the 1990s as a way to save highly erodible soils and store carbon in the soil. Farmers nationwide were encouraged, sometimes with cash payments, to stop cultivating their land and to plant native and perennial

STEPHEN AUSMUS (D1540-2)

Plant physiologist Jack Morgan (left) and soil scientist Ron Follett (right) discuss research projects at ARS GRACEnet sites across the United States while physical science technician Ed Buenger conducts mass spectrophotometer analysis of soil samples for carbon and nitrogen.

STEPHEN AUSMUS (D1621-4)

Using closed vented chambers, biological science aide Rochelle Jansen (right) and soil scientist Jane Johnson collect gas emissions from soil. Samples will be analyzed for carbon dioxide, nitrous oxide, and methane with a gas chromatograph.

grasses. But the demand for biofuels in recent years is prompting some farmers, particularly in the Midwest, to switch to corn.

Follett and his team converted the bromegrass field into no-till corn and controlled weeds chemically. He periodically collects soil samples at three depths and analyzes them for organic carbon. Previous studies predicted massive releases of organic carbon from fields converted from grass to corn or other energy crops. But that work, says Follet, “was based on the assumption that you had to plow extensively to raise corn in these areas, and that just isn’t the case.”

After 6 years of work, Follett found that by using a no-till method, there was no loss of organic carbon and that its levels didn’t change significantly at any soil depth. The pattern held even in drought years, when dried, parched soil conditions should have exacerbated release of soil carbon.

STEPHEN AUSMUS (D1541-1)

Biological science aide Lindsey Dowswell prepares to separate soil aggregates while physical science technician Ed Buenger washes a separated aggregate sample off of a soil sieve into a container to determine the amount and origin of the carbon sequestered in the sample.

Alternative Ways To Grow Wheat

Soils in eastern Oregon are relatively low in organic carbon, and research is under way to prevent further losses. Wheat farmers there traditionally plant winter wheat one year, leave the field fallow for a season, and use conventional tillage before the next wheat planting.

Hero Gollany, an ARS soil scientist and GRACEnet participant in Pendleton, Oregon, is using alternative tilling and crop rotation systems to increase the amount of carbon sequestered in the soil and reduce release of greenhouse gases.

Gollany is looking at three scenarios. In one set of plots, she is comparing the traditional 2-year, wheat-fallow rotation with a 3-year cycle of no-till winter wheat, followed by a second crop of no-till winter wheat, followed by sorghum. She is measuring residue yields, soil organic carbon, and greenhouse gas emissions (carbon dioxide, methane, and nitrous oxide). Throughout the year, she obtains gas samples from specialized chambers installed in the field and measures the samples in the laboratory. During the growing season, she takes measurements once or twice a week, depending on the weather. Because precipitation usually increases nitrous oxide emissions from the soil, she also collects data after any rain or snowfall.

In scenario two, winter wheat is grown continuously, and the untilled soil is directly seeded each year. The third system is also wheat-fallow, but it uses sweep tillage and a rod-weeder to control weeds. Sweep tillage is a low-impact method of plowing 4 to 5 inches into the soil. It is less destructive to soil than conventional tillage and is believed to help soil retain more organic matter and moisture. Previous experiments show a 14-percent increase in soil organic carbon in the sweep tillage system compared to the moldboard system. Gollany is still evaluating results of the greenhouse gas measurements.

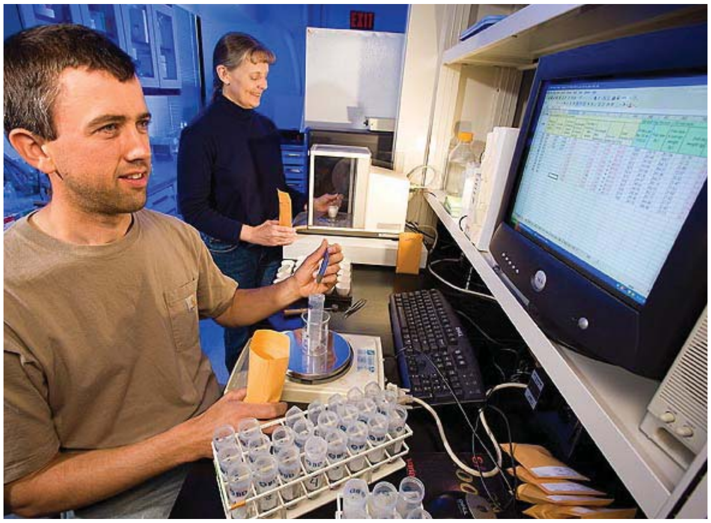
Gollany also is upgrading CQESTR, a computer model that simulates the effects of climate, soil type, cropping systems, and other management practices on soil organic carbon. Soil organic carbon is a key indicator of how well soil will hold moisture, provide nutrients, and remain productive. Gollany’s goal is to make CQESTR more user friendly so land managers, researchers, and conservationists can use it in different ways. For example, it could be used to determine the effectiveness of carbon sequestration efforts among farmers participating in carbon trading programs.

Seeking Ways To Reduce Greenhouse Gases

The cool soils of Minnesota have the potential to store a lot of the organic carbon that gives soils a dark or black color. So Jane Johnson, a soil scientist at the North Central Soil Conservation Research Laboratory in Morris, Minnesota, is exploring alternatives that will appeal to farmers, increase the carbon stored in the soil, and reduce the amount of greenhouse gases released.

Many farmers in Minnesota rotate corn and soybeans in a 2-year cycle, using aggressive tillage and fertilizer. Johnson rotated corn and soybeans on one set of plots that were fertilized and tilled every year with a chisel or moldboard plow. She is comparing that to a 4-year rotation with less-disruptive tillage, with and without adding fertilizer. The less-disruptive system is

STEPHEN AUSMUS (D1623-4)



Biological science technician Chad Rollofson (left) and soil scientist Jane Johnson weigh soil samples for analysis to determine how soil carbon and other chemical properties are changing due to management over time.

called “strip tillage” because only narrow bands of soil are tilled instead of the entire field. The four crops grown in rotation are corn, soybean, wheat, and alfalfa, with one crop grown each year during the 4-year cycle.

She also included unfertilized plots as a scientific control.

“We used realistic scenarios, ones that farmers were using or would use if there is a benefit to using them,” Johnson says.

Like Gollany, Johnson uses the specialized chambers to measure the levels of carbon dioxide, methane, and nitrous oxide released throughout the entire year. Soil is collected with a probe to determine the amount of organic carbon sequestered in it.

Johnson is still analyzing data on carbon sequestration patterns. She found no consistent pattern to methane release. And no matter which tillage or crop rotation system was used, nitrous oxide emissions peaked during spring thaws when the sun’s rays began to warm the soil.

Chisel and moldboard plowing increased carbon dioxide emissions for a short time. But measured over the course of a year, carbon dioxide emissions were no different from plots with intensive tillage than from plots without it.

Johnson is finding that when measured over the course of a year, greenhouse gas releases are largely the same under 2-year and 4-year rotation systems and that applying nitrogen fertilizer has less overall impact on nitrous oxide emissions than anticipated. The test plots were managed to match nitrogen application with nitrogen use, which may have reduced nitrous oxide emission.

“You have less nitrogen available for loss if it’s being used where you want it, in the plant,” Johnson says.

Her results show that reducing emissions is more complicated than just cutting back on nitrogen fertilizers and changing crop rotation cycles. “By shifting from one rotation to another, we’re not affecting greenhouse gases all that much, and it looks as if it’s more complex than reducing the amount of fertilizer,” she says.—By **Dennis O’Brien,** ARS.

The research is part of Global Change, an ARS national program (#204) described on the World Wide Web at www.nps.ars.usda.gov.

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Aerial view of GRACEnet test plots at the Columbia Plateau Conservation Research Center in Pendleton, Oregon.