Catching carbon on the Palouse

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As the wind sweeps across the wheat fields of eastern Washington, it carries air laden with carbon dioxide (CO_2) down to the crop surface, where daytime photosynthesis pulls the CO_2 from the atmosphere and converts it to the building blocks of roots deep in the soil and the growing vegetation at the surface. At the same time, this biological process steadily breathes or respires some CO_2 back into the atmosphere from the soil and the plants. The balance between carbon uptake during photosynthesis and carbon respiration from soils and vegetation determines whether managed cropland provides a net storage reservoir or sink for carbon from the atmosphere.

IMPACT

The balance between uptake of CO_2 during photosynthesis and release of CO_2 during respiration from soils and vegetation determines whether managed cropland provides a net storage reservoir for carbon from the atmosphere. State-of-the-art eddy covariance flux towers are being used by REACCH scientists to measure the long-term net flux of CO_2 from different cropping systems in our region. Differing CO_2 dynamics in different systems and over time are allowing us to develop a complete description of the carbon budgets from wheat-based cropping systems across our region.

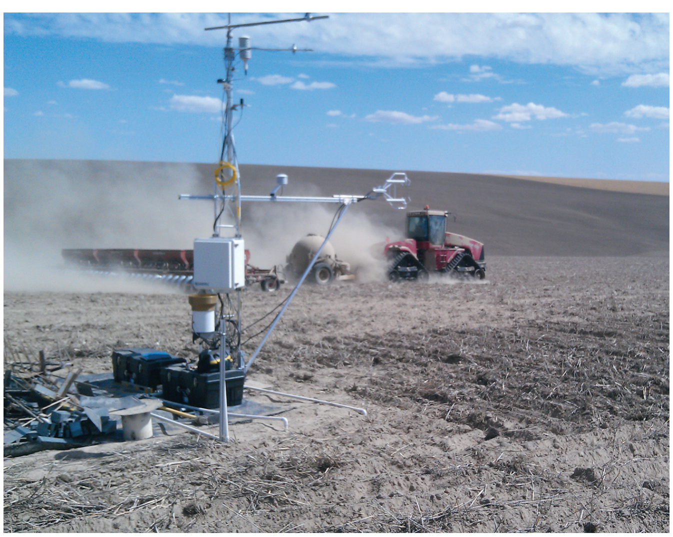
Within the REACCH project, key questions are: Do croplands act as a net sink for carbon from the atmosphere? If so, what is the magnitude of this storage? And, most importantly, can different management approaches increase the amount of carbon stored? To answer these questions, methods are needed that take a long-term look at carbon uptake and loss, and these methods must account for how the hot growing days of summer and the cold, snowy periods in winter affect carbon cycling between the atmosphere and the surface.

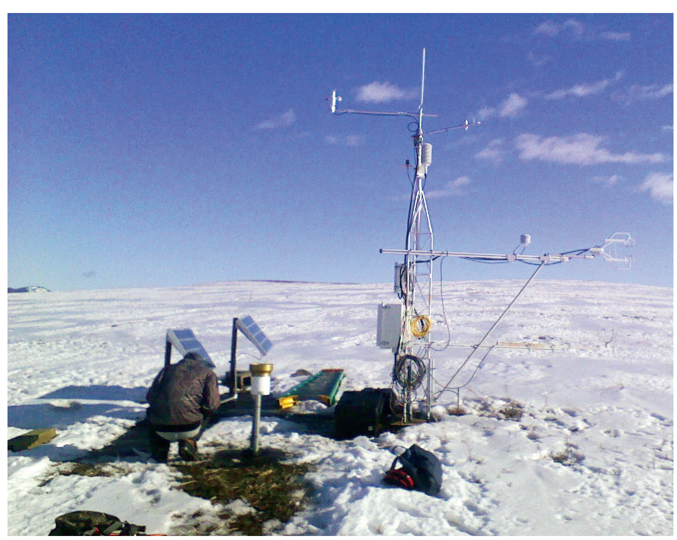
Fortunately, as a result of technological advances over the past several decades, a reliable, sensitive method now exists that can help answer these carbon storage questions. The so-called eddy covariance method relies on ultra-fast measurements of the amount of CO_2 associated with the updrafts and downdrafts from atmospheric eddies embedded in the winds traveling across the Palouse. For REACCH, we have deployed eddy covariance flux towers (Figure 1) at five sites stretching from the irrigated and dryland farming regions in the central basin near Moses Lake and Lind, Washington, to the much wetter rolling hills of the Palouse near Pullman, Washington, and Moscow, Idaho.

At each site, a sensitive sonic anemometer measures the vertical speed of updrafts and downdrafts 10 times a second, while an open path infrared gas analyzer (IRGA) measures the corresponding CO_2 content of these eddy motions. The results are beamed back to our laboratory at Washington State University in Pullman each night. The balance between carbon uptake and loss—called the CO_2 flux—is then calculated for each 30-minute period every day throughout the year. Similar measurements for water vapor fluxes are also collected. Other weather observations include temperature, humidity, the amount of sunlight, and the amount of precipitation, along with data describing soil temperature and moisture conditions. All of the data are combined daily throughout the year.

During the growing period, there is a strong signal of carbon uptake due to photosynthesis, which far outweighs any carbon loss due to respiration. This is shown as the large dip or negative peak in the graphs shown in Figure 2. The pattern is the same at both the dryland wheat/fallow rotation growing area near Lind, Washington, and the annual crop rotation near Pullman, Washington. However, there are distinct differences at these two locations in terms of the timing of the peak uptake (earlier

Figure 1. *The eddy covariance flux tower installations at (below left) Lind, Washington, during tilling operations, and (below right) Cook Agronomy Farm, Washington, in winter. Photos by Patrick O'Keeffe.*





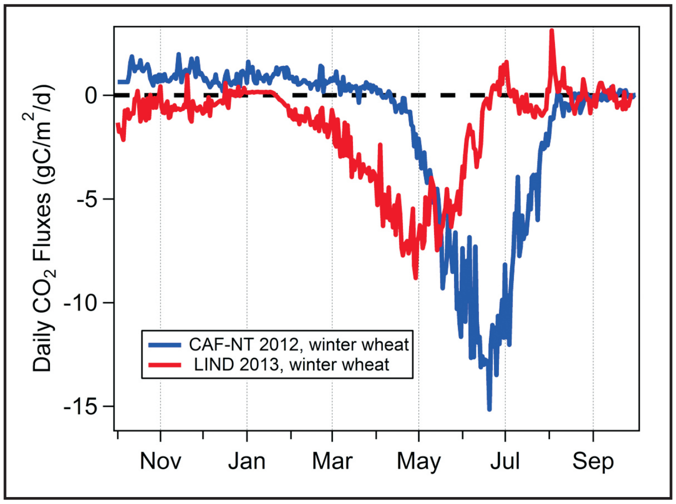


Figure 2. *Daily net carbon flux for the wheat/fallow rotation near Lind, Washington (red line), and the annual crop rotation near Pullman, Washington (blue line). Negative numbers represent the net uptake of carbon from the atmosphere due to photosynthesis.*

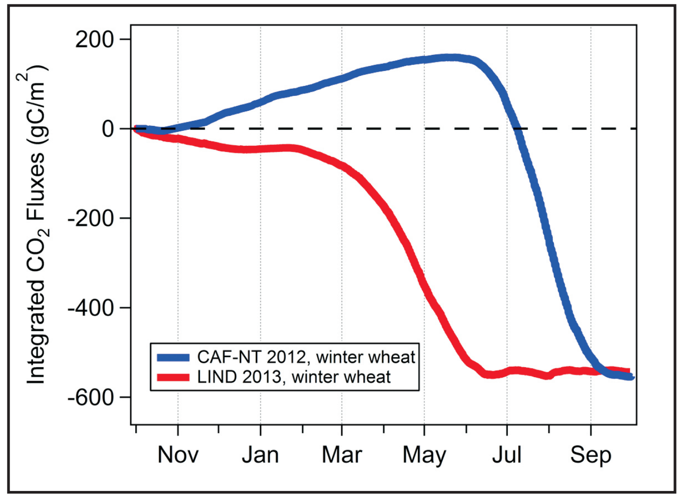


Figure 3. *The net ecosystem exchange (NEE) or net carbon uptake and loss through the 2012 crop year at the Lind wheat/fallow rotation site (red line) and the Pullman annual crop rotation site (blue line). Negative values indicate a net uptake of carbon from the atmosphere.*

at Lind) and the magnitude of the uptake (much larger near Pullman). These differences reflect the differences in productivity of the soil and corresponding crop yields for the two locations.

When the daily balance is summed continuously through the year, the results map the net carbon balance from month to month (Figure 3). Beginning in the fall, with winter wheat planted, net carbon is lost at the Palouse site until the growing season begins in early summer, when the carbon balance shifts sharply to net uptake. The wintertime loss of carbon is likely due to the breakdown of plant residue—the stalks and leaves left on the field after harvest of the previous crop. Near Lind, growers leave the field fallow every other year to conserve water. Since there is no plant residue left on the field to be broken down, we see a slight carbon uptake through the winter as the crop begins to grow. In early spring, carbon uptake increases until it reaches its maximum in June.

To determine the overall amount of carbon sequestered by a given field for a given year, the amount of carbon in the harvested crop must be taken into account. For the Pullman site in the 2012 growing season (Figure 3, blue line), approximately 290 g C/m^2 was exported, or about half of the measured net ecosystem exchange (NEE). This means that about 300 g C/m^2 is stored in the field either as residue at the surface or in the roots below ground.

Overall, the eddy covariance method provides a reliable way to measure the carbon balance for different growing zones and different management approaches. As the REACCH program proceeds, data collected at all of the tower sites will be used with other REACCH components, such as growing chambers and crop models, to develop a complete description of the carbon budget for wheat cropping systems across eastern Washington and Oregon and in northern Idaho.

PhD student Jackie Chi collecting biomass samples at the Cook Agronomy Farm flux site. Photo by Laurel Graves.