5.2: Corn Field Ecosystem Products and Services Reading

Figure 1. The US Midwest states are shown in color. Source: Nick Roux, Creative Commons.

Growing food is necessary for human survival. The Midwestern US (Figure 1) produces about 60% of the corn harvested in the US. Crop production is an important ecosystem service, and food is an important ecosystem product! In the Midwest, nearly half of the land area is used to grow crops. Because agriculture is a major land use, it plays an important role in the region's energy flow and carbon cycle. Here we will explore carbon cycling in a typical Midwestern corn (*Zea mays*) field and how farm management can affect tradeoffs among ecosystem services.

A Walk through the Corn Field

Here are some pictures that show what you would see in a walk through a Midwestern Corn field or a drive through the Midwest. From planting to harvest, corn takes about six months to grow. This is corn used for grain. This kind of corn is used primarily as livestock feed, biofuel, and corn syrup. It is different from the sweet corn we eat on the cob.


Figure 2.. Young ears of corn. Source: KBS LTER


Figure 3. Corn ready for harvest. Source: KBS LTER

In Figure 2 you can see young ears of corn and the silk at the top of each ear. Each thread of silk captures a grain of corn pollen from the wind, which then grows down into an egg (kernel), fertilizing the corn grain. That has to happen for each individual kernel to be fertilized!

Corn can grow to be 7 to 10 feet tall built from carbon absorbed through photosynthesis. The corn grain is harvested late in the fall after all the leaves and stalks have died (see Figure 3). The leaves and stalks (stover or residue) can be left on the field or harvested to use as bedding for animals or biofuel. When the stover is left on the field, decomposers in the soil break down these materials, respiring some of it away as carbon dioxide (CO_2) and converting some of it into soil organic carbon, an important pool of carbon that keeps it out of the atmosphere.

The pictures of the corn field above show some evidence of carbon pools and fluxes—can you identify them? Some pools and fluxes are invisible, but still essential to the functioning of the ecosystem.

Carbon Pools and Fluxes in the Corn Field

Let's take a closer look at those pools and fluxes. Figure 4 (next page) shows the pools and fluxes for an individual corn plant and its soil. The corn's carbon inputs (photosynthesis and last year's corn stover) are equal to the amount of carbon outputs (harvested carbon, respiration from plants and decomposers, and stover that will be respired next year).

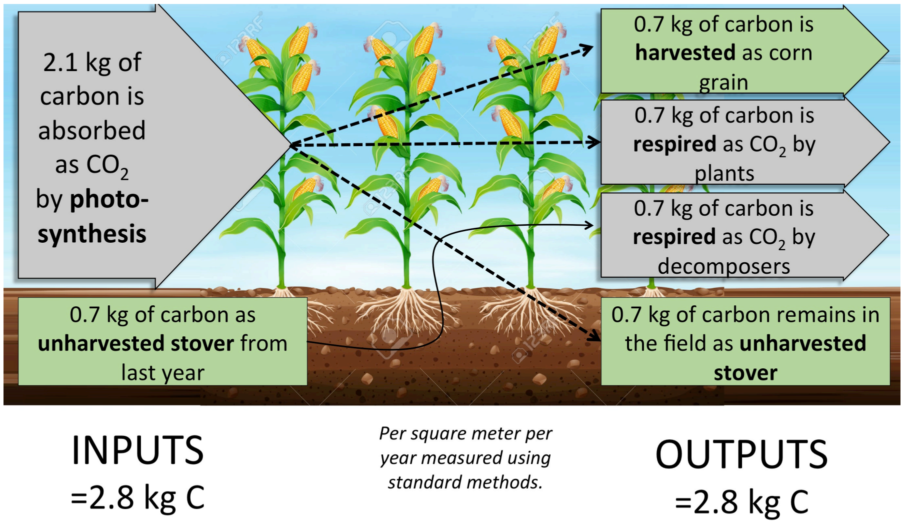

Figure 4. Carbon fluxes for a corn plant per year.

Carbon pools. Now, let's consider the entire corn field as an ecosystem (Figure 5). The *visible* carbon pools are mostly *organic carbon pools,* primarily producers (corn plants). Note that a farmer tries to keep consumers (deer, cows, insects) *out* of their corn fields!

There is a lot of organic carbon in these visible pools—Midwestern row crop farms have some of the highest crop yields in the world. Corn yields in the Midwest can range from about 3 to 7 megagrams of carbon as grain per hectare (Mg C ha^{-1}). (Note: A megagram is 1 million grams—about one ton—and a hectare is 100 x 100 m area—about 2.5 acres.)

But there is also carbon sequestered in carbon pools that we can't see in the photos. Much of this is *soil organic carbon*—all the plant roots and decomposed organic materials (leaves, plants, animals, bacteria, fungi) in the soil. The upper 1 meter of soil in a corn field stores about 7 kilograms of carbon per square meter (kg C/m^2). Soil organic carbon is important for several reasons. 1) It stores carbon away from the atmosphere, reducing climate change. 2) It provides soil structure that helps plant roots grow and holds moisture during dry periods. 3) Along with the carbon, soil organic matter stores other nutrients like nitrogen that plants need.

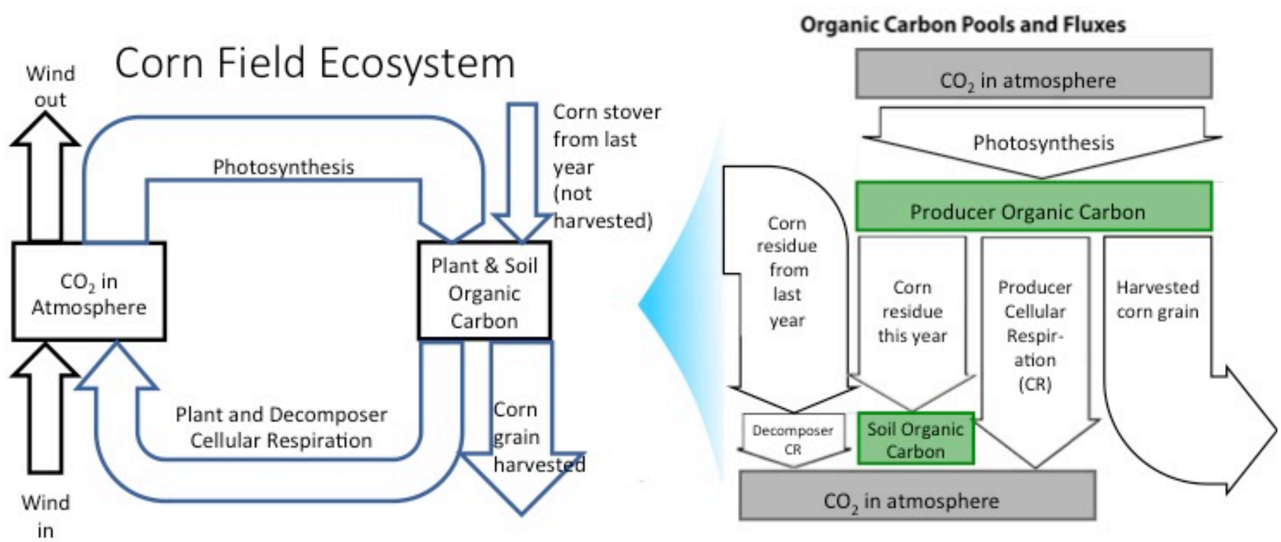

Figure 5. The main carbon pools and fluxes in the corn field.

Another invisible pool of organic carbon in the soil is the living bacteria, fungi, and invertebrates (for example, earthworms). These are important for decomposing organic material like dead plant leaves into smaller pieces of carbon that contribute to soil organic carbon. Yet another invisible pool of carbon is the CO_2 in the air—this is an inorganic pool. The concentration of carbon dioxide in the air on Earth is, on average, about 405 parts per million carbon dioxide (ppm CO_2) as of 2017 (why do you think it is important to note the date here?).

Carbon fluxes. Carbon is constantly moving among the pools in the corn field and beyond. A major flux is when a farmer harvests the corn and hauls it away to feed to livestock or sell—a carbon output. Photosynthesis is also visible in that you can see the green leaves of the corn plant and the growth of the plant over time. But other fluxes are invisible, such as cellular respiration from producers, consumers (though there aren't many here), and decomposers. Corn stover is a pool of carbon that decomposers mainly use for cellular respiration and exhale as CO_2.

The fluxes are mainly balanced, that is the carbon inputs are almost equal to the carbon outputs. More specifically, the amount of carbon photosynthesized in a year in the corn field is balanced by the amount of carbon leaving the system as CO_2 or harvested grain. The carbon in the last year's corn stover is equal to the amount of CO_2 respired by decomposers this year. So, the soil organic carbon pool does not change.

Ecosystem Products and Services


Fig. 6. Nitrogen fertilizer application to early corn plants. Source: KBS LTER.

Human management (Figure 6). In order to harvest the greatest amount of corn possible, farmers must do a few things to help the corn grow. For example, Figure 2 shows a farmer applying nitrogen fertilizer to young corn plants. Other practices might include tillage (plowing), pesticides (to kill weeds or insect pests), and irrigation.

Farm products. A corn field provides one major ecosystem product and a few ecosystem "dis-services"—harming other parts or processes in the ecosystem. The ecosystem product is food: Corn fields are managed to maximize this ecosystem product, which feeds humans and livestock such as cattle, pigs, and chickens—most of the meat that we eat.

Tradeoffs: What services does the corn farm NOT provide? What would happen if this same land was abandoned from agriculture and we let succession—the natural progression of plant communities from annuals to perennials to forest—take over?


Figure 7. Ladybugs eating aphids (yellow). Source: KBS LTER.

10 years after abandonment, this field would likely have milkweed, goldenrod, and other "old field" plants growing in it. It would no longer pollute the stream with nitrogen or loose soil, it would sequester about 100 g of carbon per m^2 per year, and it would provide habitat for many more species of wildlife than lived there when it was a corn field.

50 years after abandonment, this field would probably have blackberries, other shrubs, and trees. It would continue to not pollute the stream, it would sequester about 50 g of carbon per m^2 per year, and it would provide habitat for wildlife that depend on forests. Wildlife would probably include ladybugs (among other creatures), who hide under tree bark to survive the winter. Ladybugs provide an important pest control service to neighboring soybean fields—ladybugs love to eat soybean aphids (a destructive pest of soybeans, Figure 7). These ladybugs can save farmers about $33 per hectare per year in pesticides.

Here are some other ecosystem services that the abandoned field would also provide better than the corn field.

- Clean water – Corn fields are not necessarily managed for clean water. Fertilizer nitrogen and eroding soil are known to runoff corn fields, polluting streams and diminishing the capacity of downstream aquatic ecosystems to provide ecosystem services, such as food, clean water, and recreation. Some farmers adopt conservation practices to minimize the amount of fertilizer and soil leaving their corn fields.
- Enough water – Where farms use water to irrigate crops, the amount of water they use could diminish the amount of water available for humans and ecosystems.
- Carbon sequestration – This field is not sequestering or emitting carbon. Sequestering carbon reduces global warming.

Digging Deeper: Where You Can Learn More about Corn Fields and Their Ecosystem Services

To learn more about corn fields and the ecosystem services and dis-services that they provide check out these links to articles, websites and videos:

- Did you know agriculture can help store carbon away from the atmosphere, mitigating climate change? The trick is to manage crops so that carbon inputs to the soil are greater than carbon outputs. Read about it in the news here: https://modernfarmer.com/2016/03/carbon-farming/
- The Fields of Fuel computer game lets you play alone or with friends as you design and manage your own row crop farm. The game allows you to compare how your management choices result in different economic, environmental, and energy outcomes. http://fieldsoffuel.org (Be sure to click on the Help button to get started.)
- Corn is a-maize-ing! How humans turned a humble grass into the corn we grow today: http://www.hhmi.org/biointeractive/popped-secret-mysterious-origin-corn
- How can increasing organic matter (carbon) in soils fight world hunger? https://drive.google.com/open?id=1qcFEI-U836ZEsPWBCVBMNF79Rj3DgRIs
- Agriculture, ecosystem services, and tradeoffs in the news: https://www.theguardian.com/environment/2016/jun/02/a-switch-to-ecological-farming-will-benefit-health-and-environment-report
- Outside the US, a lot of wild lands are being logged or drained to make way for agriculture. Often forests are burned, which is a large flux of carbon from wood to CO_2. https://nyti.ms/2DD4xS0