Soil respiration

Soil microbes and plant roots release CO₂ as they respire. Therefore, the amount of CO₂ that leaves the soil surface is a result of this biological respiration. A system that releases large quantities of CO₂ from soils is the trait of an active soil system and vice versa.

However, if large quantities of CO₂ are released, the same amount or more carbon must be put back into the soil, primarily through roots, to sustain an active and productive system.

At the COBS site, prairie systems tended to release more soil CO₂ than the corn systems. This data compliments the measured soil microbial biomass and root growth as compared to the corn systems, indicating a more active and healthier soil biological system. In the corn systems, the harvesting of a portion of stover as a bioenergy feedstock changed the field average CO₂ released from soil; even though half of the carbon that would have been left to decompose and contribute to soil organic matter had been removed. These measured data suggest that soil carbon losses via soil respiration may result in a net loss of soil carbon if stover removal persists into the future without a means of supplementing input carbon. This is also supported by observations of enhanced spatial variability in soil respiration when stover is harvested, as compared to stover left on the soil surface even though field averages remained similar.

References
Why is carbon important?
The element carbon (C) is the basic building block of living organisms. All living organisms use carbon to build cells and tissues and to transfer and store energy. Plants obtain carbon through photosynthesis, using energy from sunlight and carbon dioxide (CO₂) from the atmosphere to produce sugars. Animals, insects, and many microorganisms consume plants (and other organisms) to obtain carbon energy from sugars and carbohydrates. Photosynthesis is the primary way carbon dioxide gas enters terrestrial pools of carbon. Plants, however, are not the largest terrestrial pool of carbon. Soil contains 2344 x 10¹⁵ g carbon globally¹—it more than plants and animals combined!

What is soil carbon?
Respiration by all living organisms, including plants, is the primary pathway for biological carbon to return to the atmosphere. Microbial decomposition of plant and animal material is the process that balances how much carbon stays in soil as organic matter and how much is respired back to the atmosphere as CO₂. Because CO₂ is a greenhouse gas contributing to global climate change, scientists are very interested in understanding the dynamics of microbial decomposition and how land use practices could facilitate carbon storage in soils. In addition, soil carbon contributes towards many aspects of soil fertility, and in turn, agricultural productivity. Therefore developing sustainable agricultural systems includes managing both CO₂ emissions and soil carbon storage.

Balancing carbon storage with agronomic goals
Agricultural practices such as tillage can increase microbial respiration and harvest can reduce plant inputs, reducing soil carbon stocks². Because many agricultural soils are considered depleted in carbon, long-term management practices that increase plant inputs, including litter and roots, and reduce microbial respiration have great potential to sequester carbon in these soils. These changes in management are not mutually exclusive with continued agricultural production.

Comparison of Biofuel Systems
Comparison of Biofuel Systems (COBS), the collaborative experiment at Iowa State University, is comparing carbon storage potential of five agronomic ecosystems:
• Conventional corn-soybean (grain harvest)
• Continuous corn (grain & stover harvest)
• Continuous corn with rye cover crop (grain & stover harvest)
• Reconstructed tallgrass prairie (biomass harvest)
• Fertilized reconstructed tallgrass prairie (biomass harvest).

Each of these systems is harvested for grain and/or biofuel feedstock. In addition to production metrics, a team of scientists is quantifying numerous environmental factors including water quality, biodiversity, and soil health, including microbial and plant contributions to soil carbon storage.

What does the research show?
Root growth
Roots are a direct carbon input from plants to soil. The reconstructed prairies included a mix of 31 perennial tallgrass prairie plants, which means the plants grow back from root stock every year without having to be replanted. In contrast, corn and soybeans are annual plants and have to be replanted each spring. Perennial prairie plantings produced substantially more roots than annual corn systems, nine times more in fertilized prairie and 11 times more in unfertilized prairie³. Even at a depth of 80cm, the prairie plantings contained more root biomass than corn systems did in the top 10cm!

Microbial biomass & activity
Soil microbial biomass in both prairie systems was twice that of the continuous corn system⁴. This indicates more organic matter is being incorporated into living fungal and bacterial cells. When these organisms die, their cells are generally more difficult to decompose than plant-derived tissues. Microbial activity was also greater in reconstructed prairies than in continuous corn systems, and fertilized prairies had slightly greater activity than unfertilized prairies. This indicates microbes are processing root inputs in the prairie systems, an important part of stabilizing carbon in soils.