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Why are Carbon Markets Focused on Agriculture and Natural Resources?

Dr. Jordan Shockley | Department of Agricultural Economics, University of Kentucky
Dr. Jacob Muller | Department of Forestry and Natural Resources, University of Kentucky
Dr. John Grove | Department of Plant and Soil Science, University of Kentucky

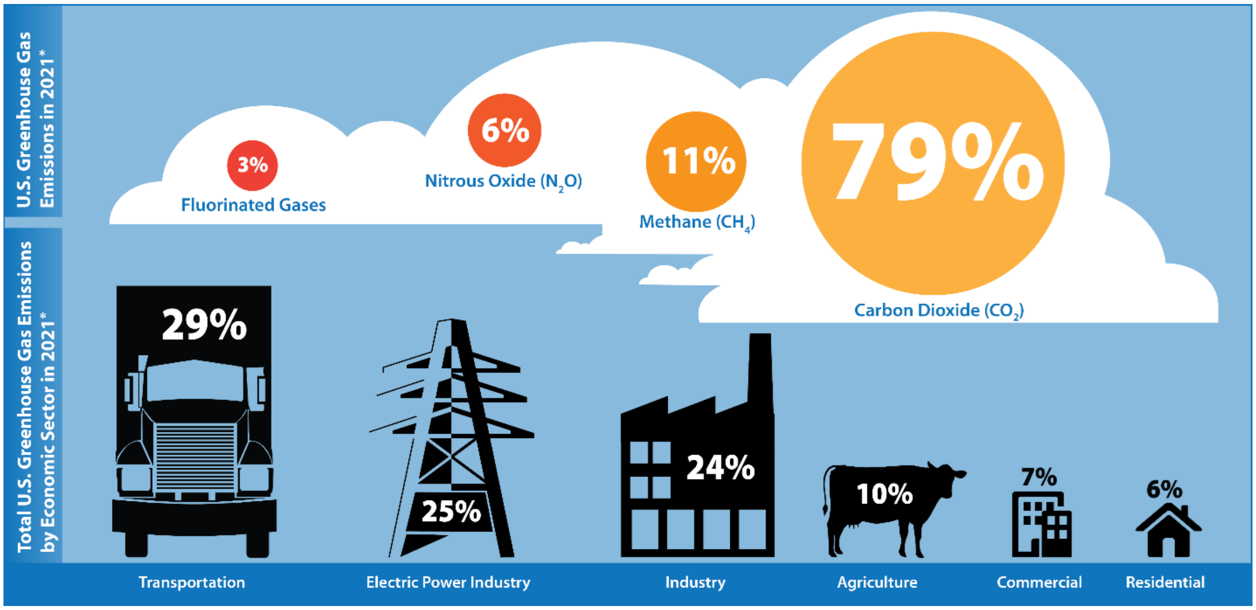
As carbon markets grow and develop across the U.S., project developers continue to focus on the agriculture and forestry sectors to generate carbon credits to meet demand. The demand in the U.S. for carbon credits comes from state cap and trade regulations on greenhouse gas emissions and companies voluntarily setting greenhouse gas reduction targets. These targets are met through purchasing carbon credits and carbon insetting strategies. More information on these strategies can be found in the "Navigating Carbon Strategies: Understanding Offsets and Insets in Agriculture" publication. The focus on the agriculture and forestry sectors stems from their role in emitting and sequestering carbon. This publication outlines the greenhouse gas emissions by sector and specific agriculture practices, methods for generating a carbon credit, and the ins and outs of soil and forestry carbon sequestration.

GREENHOUSE GAS EMISSIONS BY ECONOMIC SECTOR AND AGRICULTURAL ACTIVITIES

According to the U.S. Environmental Protection Agency Inventory of greenhouse gas emissions by economic sector, agriculture ranks 4th in the U.S. for greenhouse gas emissions. The main greenhouses gasses in agriculture are carbon dioxide (CO2), nitrous oxide (N20), and methane (CH4). The transportation sector leads the way, which accounts for 29% of U.S. greenhouse gas emissions, while agriculture accounts for 10%. Figure 1 illustrates U.S. greenhouse gas emissions in 2021 by economic sector. In agriculture, most greenhouse gas emissions come from crop cultivation and livestock production. Figure 2 illustrates that in 2021, crop cultivation and livestock production equated to 50% and 44% of the total greenhouse gas emissions in the agriculture sector, respectively (U.S. EPA, 2024). Specifically, nitrous oxide emissions from fertilizer and methane emissions from rice paddies are primary greenhouse gas contributors reported in the crop cultivation category. Furthermore, methane emissions are the primary greenhouse gas contributor in the livestock production category. While there are a number of greenhouse gases, each of which vary in magnitude on their impact on the atmosphere, carbon dioxide equivalent (CO2e) is used as a standard measure to compare emissions from different sources.

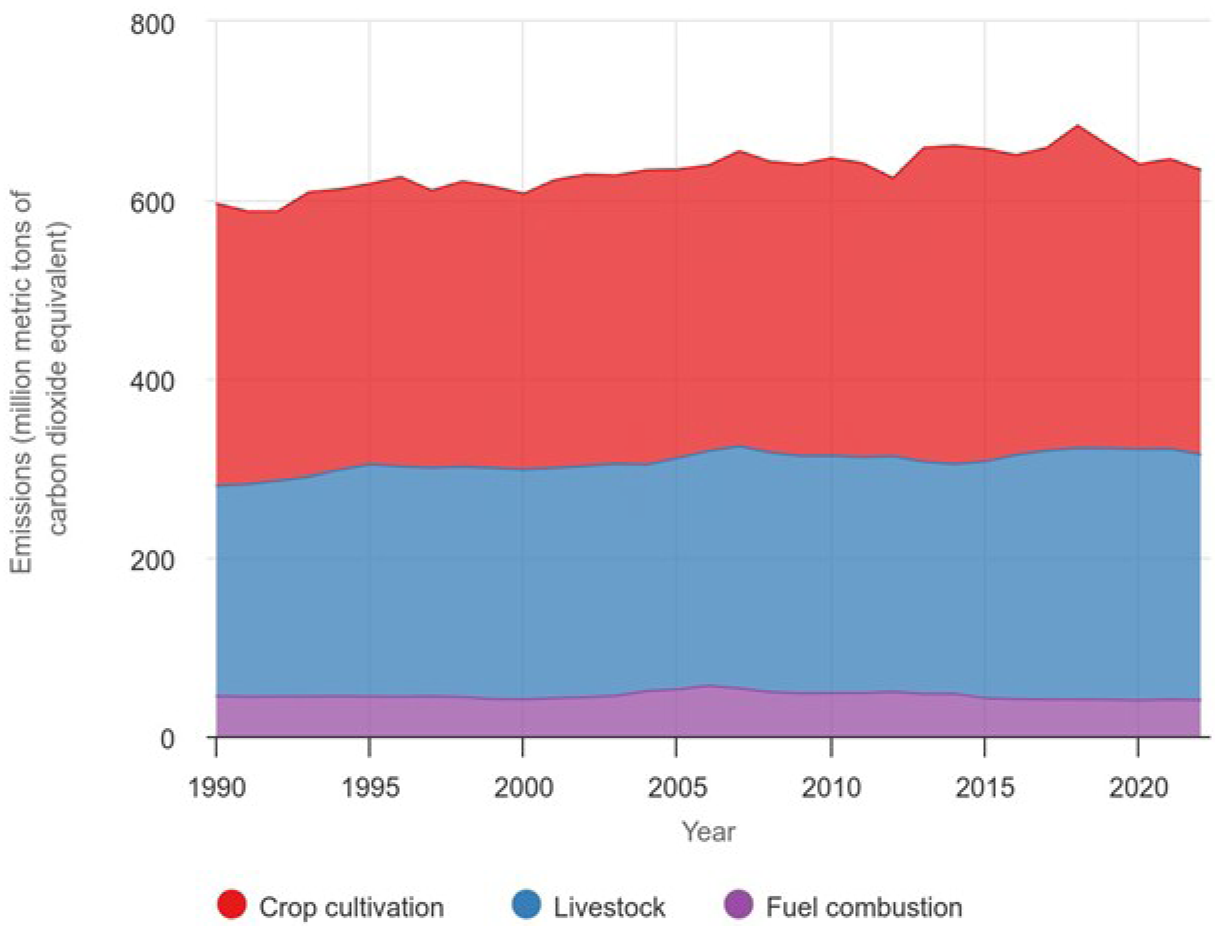
Some agricultural activities can be adopted to reduce greenhouse gas emissions, such as using no-tillage or other conservation tillage, planting cover crops, optimal nitrogen management, improving grazing practices, and utilizing methane digesters. Project developers incentivize agricultural producers through contractual arrangements and subsequent payments for practices that generate carbon credits (1 carbon credit = 1 MT of CO2e).

Figure 1. Percentage of U.S. greenhouse gas emissions in 2021 by economic sector (bottom icons) and by greenhouse gas (top circles).



Source: U.S. Environmental Protection Agency. Greenhouse Gas Inventory Data Explorer

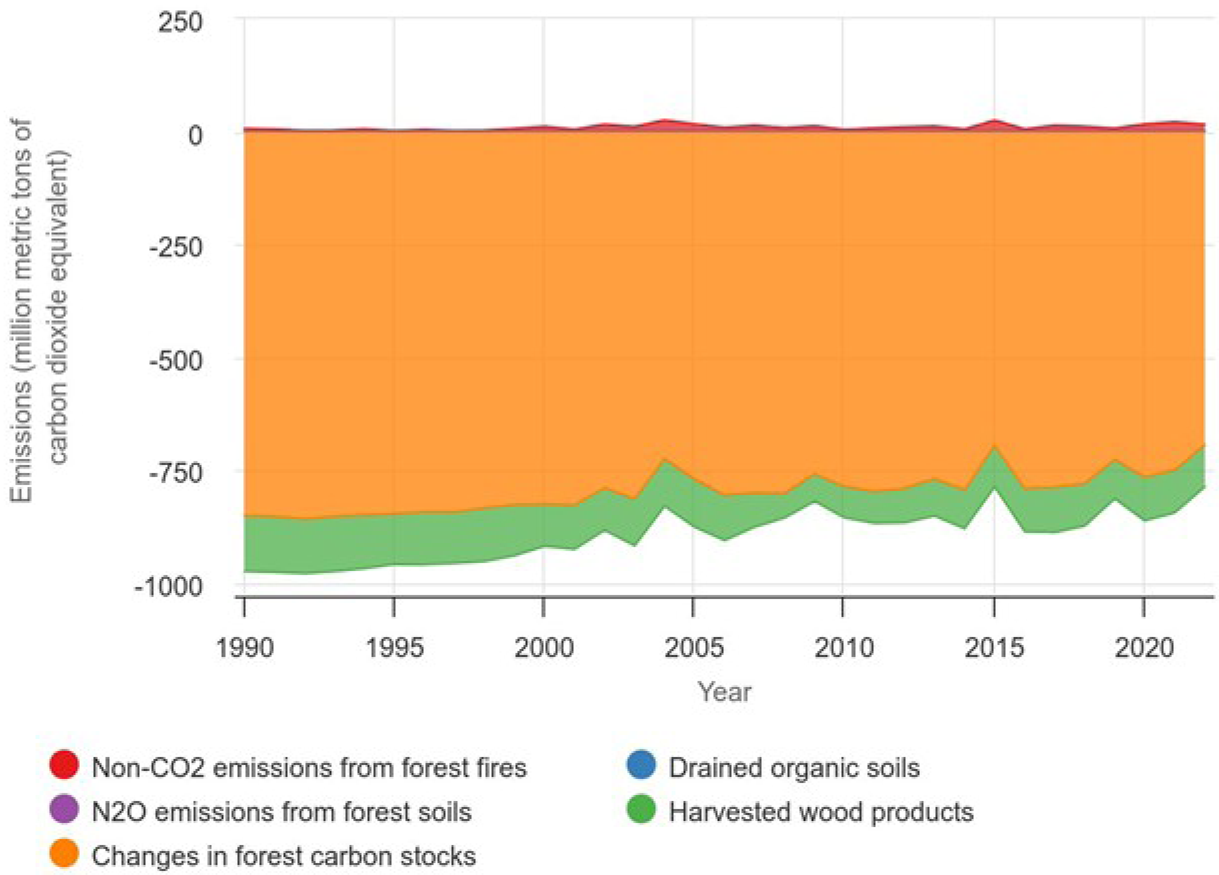
Figure 2. U.S. Greenhouse gas emissions from the agriculture sector from 1990-2021



Source: U.S. Environmental Protection Agency Inventory of U.S. Greenhouse Gas Emissions and Sinks

On the other hand, the forestry sector is a net sink regarding greenhouse gas emissions. This means that forest lands sequester more greenhouse gases than they emit. However, while minimal in comparison to the amount of greenhouse gasses the forestry sector sequesters, greenhouse gas emissions occur through forest fires and forest soil processes. Figure 3 illustrates the amount of greenhouse gas removal from forest lands in the U.S. Since forest lands are a carbon sink, project developers in the forestry sector are incentivizing woodland owners not to harvest their current timber or participate in afforestation and reforestation projects. According to the U.S. Department of Agriculture (2023), 59% of all carbon credits issued for projects in the U.S. from 2013-2022 were generated from the forestry sector. This is far more than the 3% issued for agriculture projects in the U.S. during the same period. Forests have the ability to generate more carbon credits per acre compared to most agricultural projects and are easier to verify compared to agricultural projects, typically minimizing verification costs.

Figure 3. U.S. Greenhouse gas emissions and removals from forest land remaining forest land from 1990-2021.



Source: U.S. Environmental Protection Agency Inventory of U.S. Greenhouse Gas Emissions and Sinks

UNDERSTANDING AGRICULTURAL SOIL CARBON DYNAMICS

In the global carbon cycle, soil carbon, as soil organic matter, is one of several storage 'pools.' Other pools include the atmosphere, oceans, and carbonate rocks. Each pool always tends towards equilibrium – an equilibrium that is not entirely stable, an equilibrium that shifts in response to other forces. Agricultural soils, under both grasslands and croplands, are more subject to changes due to human management than other soils. Soil carbon/organic matter levels result from the net impact of additions and losses. Additions take the form of plant (especially roots) and animal residues, and losses consist of carbon dioxide (CO2) gas due to mineralization/oxidation of organic matter, drainage water bicarbonate (in certain seasons), and erosion/runoff containing particulate/soluble organic materials. Warm temperatures, adequate but not excessive moisture, and soil disturbance (tillage) increase organic matter oxidation and carbon loss as CO2 gas. Some soil CO2 losses are the result of agricultural lime (usually carbonate rock) application to reduce otherwise increasing soil acidity due to the use of nitrogen fertilizers and mineralization of plant (especially legume) residues.

Good soil structure, cool temperatures, and adequate to excessive moisture (soil saturation) tend to slow oxidation and preserve already formed organic matter. Increased plant dry matter production (photosynthesis-driven higher yield) causes greater plant C residue additions. In agroecosystems, greater productivity is achieved by reducing plant growth limitations due to nutrient and water availability with fertilizers and irrigation, respectively. These practices are not themselves principal practices used for carbon offsets in agriculture since greenhouse gases from fertilizer manufacturing and irrigation water pumping can reduce the soil carbon storage offset. Additions of compost, manure, biochar and biosolids can also raise soil organic matter levels. However, these materials may have other uses that result in greater offset value, given their instability with soil amendment. Keeping the soil under continuous living plant cover, especially between cash crops; including grass, grass-legume or legume sod-forming crops within an otherwise grain crop rotation; and using more intensive rotation grazing in grasslands all promote root carbon cycling and organic matter formation.

Carbon sequestration as soil organic matter also causes the immobilization (sequestration) of nitrogen (N), phosphorus (P) and sulfur (S). One ton of additional soil organic matter (increases the soil organic matter by 0.1 %) contains about 1200 pounds of C (Havlin et al. 2014) and will tie up about 100 pounds of N, 13 to 14 pounds of P (equivalent to 30 pounds of P2O5) and 13 to 14 pounds of S (Stevenson, 1986). The value of these elements as plant nutrients warrants consideration when agricultural soil carbon sequestration credits are being traded.

UNDERSTANDING FOREST CARBON DYNAMICS

Trees play a vital role in the ecosystem through a process called photosynthesis. During this process, leaves absorb sunlight and draw in CO2 from the atmosphere, which, combined with water from the roots, creates sugars and oxygen. The sugars are distributed throughout the tree, while the oxygen is released back into the air. Carbon cycles through forested ecosystem, with nearly 50% stored in the soil, about 40% in the tree trunk and branches, and roughly 10% in the roots. When trees age and die, they decay releasing carbon back into the soil and atmosphere as CO2. This highlights the importance of understanding both carbon storage, which refers to the carbon contained in tree tissues and soil, and carbon sequestration, the process by which trees absorb additional carbon through photosynthesis, resulting in a net transfer of carbon from the atmosphere to the forest over time. This can be likened to a savings account: storage is the principal amount, and sequestration is the accruing interest. Younger forests, while not storing as much carbon, tend to sequester carbon at a higher rate than mature forests.

CARBON OFFSET MARKETS IN AGRICULTURE AND FORESTRY

Participation in carbon markets in agriculture often requires an initial assessment of soil carbon status, focused management to raise soil carbon levels, and a later assessment to assure the market of positive progress towards credit/contract numerical goals. Some market participants merely require documentation of the execution of specific soil carbon sustaining practices without initial or final soil carbon assessment. Initial assessment can be important where the soil's organic matter level might be anticipated to be high, where further increases would be difficult and expensive to achieve.

Meeting contract goals can cause the cropland manager to introduce no-tillage practices, insert cover crops and/or perennial crops into the rotation, and optimal nitrogen management. Pasture grassland managers might consider more intensive (mob) rotation grazing, fall stockpiling, bale grazing, or some combination of all three. As with forest land management, agricultural soil carbon management can complement other program objectives like pollinator habitat and wildlife conservation, thereby enhancing overall sustainability. Natural Resources Conservation Service (NRCS) has programs that support conservation practices like cover cropping, which helps maintain soil carbon levels. Soil carbon and credit offset markets provide even more opportunities for landowners to be rewarded for practices that increase soil carbon.

Achieving sustainable forestry requires a future-focused management plan that incorporates diverse approaches such as reforestation, retaining mature trees, and reassessing rotation ages for harvesting. Effective carbon management aligns with broader goals like wildlife conservation and recreational use, making carbon-focused practices inherently sustainable. While harvested trees store much of the carbon in products like furniture, timber harvesting inevitably carries a carbon footprint. Each forest action, including timber removal, has its own costs and benefits, making informed decision-making crucial for landowners. Programs like NRCS funding and forestry certifications offer valuable resources to guide these decisions. Additionally, the rise of forest carbon markets incentivizes the adoption of sustainable practices by offering financial incentives to landowners. Companies purchase carbon credits which are generated from the adoption of sustainable practices and/or the retention of trees to offset their emissions. Eligible carbon projects for generating these credits include afforestation, avoided conversion, and improved forest management. Landowners should consult with foresters to assess the best options for their properties, carefully weighing the costs and benefits of each project.

SUMMARY

As carbon offset markets continue to develop, agriculture and forestry sectors are increasingly involved in carbon sequestration efforts to generate carbon credits. Understanding carbon dynamics, including emissions and storage, enables landowners to participate in these markets by adopting practices that sequester carbon dioxide. Engaging in sustainable soil and forest management through carbon offset markets provides financial incentives to support land stewardship objectives. However, it is imperative that you consult with experts and seek legal advice before enrolling in a carbon offset program.

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