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Carbon: The Next Big Cash Crop?

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Abstract

With the release of the Intergovernmental Panel on Climate Change's (IPCC) revised forecast predicting even greater global warming effects than previously believed, the interest in methods to reduce the atmospheric concentration of greenhouse gases (GHG) is almost certain to grow. Agriculture is unique in that it has the potential to generate greenhouse gases (Schneider and McCarl, 1999), as well as to sequester (or store) large amounts of carbon and other

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AGRICULTURE'S ABILITY TO STORE CARBON IN THE SOIL COULD PROVIDE ENVIRONMENTAL BENEFITS AND POSSIBLE ADDITIONAL INCOME FOR FARMERS. BUT WILL ONE NATION'S MULTIFUNCTION BE ANOTHER'S AGRICULTURAL SUBSIDY?

Carbon

The next big cash crop?

BY HONGLI FENG, JINHUA ZHAO, AND CATHERINE L. KLING

With the release of the Intergovernmental Panel on Climate Change's (IPCC) revised forecast predicting even greater global warming effects than previously believed, the interest in methods to reduce the atmospheric concentration of greenhouse gases (GHG) is almost certain to grow. Agriculture is unique in that it has the potential to generate greenhouse gases (Schneider and McCarl, 1999), as well as to sequester (or store) large amounts of carbon and other greenhouse gases in its soil (Lal et al., 1998). The activities that may enhance the storage of carbon in agricultural soils include planting trees, converting from conventional to conservation tillage, adopting improved cropping systems, converting to perennial crops, and restoration of wetlands, among others.

Experts estimate cropland in the United States has the potential to sequester 75-208 million metric tons of carbon equivalence per year (MMTC/yr). On average, this is about 8 percent of total U.S. emissions of GHGs or 24 percent of the U.S. emission reduction commitment under the Kyoto Protocol (Lal et al.). Figure 1 shows the distribution of carbon sequestration potential across different agricultural practices. Clearly, conservation tillage and residue management improvement have the most potential to sequester carbon in agricultural soil.

Paustian et al. (2000) estimate that, in Iowa, for a corn-soybean rotation, conversion from conventional to no-till could increase carbon storage rates by about 550 kilograms per hectare per year (Figure 2); for land enrolled in the Conservation Reserve Program (CRP), the rates range about 1500 kg/ha/yr (Figure 3). At an assumed payment rate of $20 per ton, the total potential revenue that C sequestration might bring to Iowa farmers is more than $100 million per year. Pautsch et al. (2001) also suggest that the income potential for Iowa farmers is substantial. Antle et al. (1999, 2000) provide similar estimates for Montana: at $30 per ton, carbon sequestration could provide $13.5 million per year for 20 years to Montana grain producers willing to switch from a crop/fallow to a continuous cropping system.

Thus, the limited available evidence suggests that U.S. farmers might substantially profit from a system that pays them for storing carbon in their soils, assuming payment rates similar to those discussed above. Moreover, practices that sequester carbon do more than mitigate greenhouse gas effects. By adopting carbon-enhancing activities, soil productivity, water and air quality, and wildlife habitats are all enhanced.

It Plays in Kyoto, But What About Kansas?

Despite the interest in carbon markets or programs that would reward agriculture for storing carbon, there are still substantive questions about how to design such mechanisms that would meet this task and be generally acceptable to the international community. Under the Kyoto Protocol, carbon sequestered through forestry is explicitly allowed. However, no role currently exists for agricultural soils. Clouding the issue further, President Bush in early 2001 announced that the U.S. would withdraw from the Kyoto regime. That issue aside, the language of the protocol clearly allows for the future admission of agricultural soil sinks. However, member countries are not likely to ratify agriculture's inclusion until key implementation issues are resolved.

One of the most significant issues is the fact that, unlike reductions in emissions, carbon sinks may only temporarily keep carbon out of the atmosphere. This characteristic of sinks applies to all forms, including forestry, but is likely to be especially problematic in the case of agriculture as annual changes in land use and management can have significant effects on carbon storage. For example, switching production practices from conventional to reduced tillage may sequester a significant amount

This is a carbon sink: Farming practices such as no-till have the potential to tie up large amounts of carbon in the soil.

Clear Window photo

This is not a carbon sink: Traditional moldboard plow practices not only do not sequester carbon in the soil, they release any previously sequestered carbon.

Clear Window photo

of carbon over several years. However, if the farmer reverts to conventional tillage, nearly all of the stored carbon will be released immediately.

All Sinks Are Temporary

Agricultural sinks may be intentionally temporary or unintentionally so. For example, a farmer may sign a contract with a broker to adopt conservation tillage practices in exchange for an annual payment for a fixed number of years. In such a case, the carbon sequestration services provided by the sink are temporary, at least potentially so.

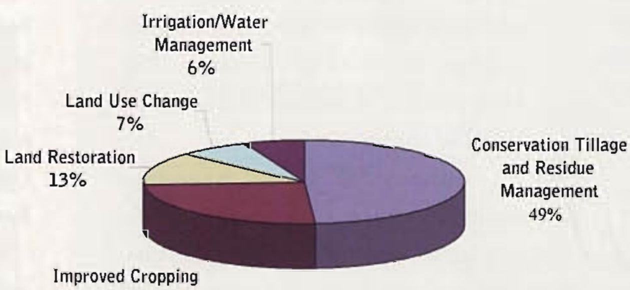
Even if both parties anticipate that the contract could be extended or renegotiated at its term, there is still the very real possibility that the farmer will choose not to do so. Second, unanticipated events may cause the early release of carbon. In the case of forestry, a fire may be the cause. In the case of agriculture, changes in crop or input prices may induce the farmer to break the contract.

It is important to note that in most situations, even temporary sinks will have positive value, albeit not as great as that associated with permanent reductions or abatement. This occurs because global warming damage is reduced while the carbon is stored and roughly returns to its former level upon release, generating a net reduction in damage.

Taking Carbon to Market: First, You Need A Market

Until policy mechanisms that properly account for the potentially temporary nature of sinks are developed, it is unlikely that agricultural carbon sequestration will gain widespread acceptance. We introduce and discuss three such mechanisms — a Pay-As-You-Go (PAYG) System, a Variable Length Contract (VLC) System, and a Carbon Annuity Account (CAA) System. These mechanisms could be implemented in the context of either a private trading market or a government program (such as green payments), but we will explain them in the context of a well-functioning external carbon market that determines the price of carbon abatement. That is, the price for one unit of carbon credit is the price associated with one unit of permanent carbon reduction.

Figure 1: Carbon Sequestration Potential of Different Improved Practices on U.S. Cropland



Source: Lal et al., 1998, page 84.

The PAYG system applies the price of one full credit for each unit of carbon released or sequestrated, with no consideration given to the permanence issue. However, as the name suggests, while a sink owner gets rewarded a full credit when she removes one unit of carbon from the atmosphere, she will also have to pay a full credit when she releases the sequestered carbon.

In the VLC system, in anticipation of the non-permanence of sequestered carbon, temporary carbon sequestration will be paid at a discounted rate. The discount will, among other things, depend on how long sequestered carbon will be kept out of the atmosphere.

In the CAA system, the generator/maintainer of a sink is paid the full carbon price, and payment is put directly into an annuity account. As long as the sink remains in place, the owner can access the earnings of the annuity account, but not the principal. The principal is recovered by the ongoing permit price if and when the carbon is released.

If the sink remains permanently, the sink owner eventually earns all of the interest payments, the discounted present value of which equals the principal itself — the permanent permit price.

Merits and Pitfalls of the Mechanisms

With perfect foresight of future carbon permit prices, each of the three systems provides an economically efficient solution to the non-permanent nature of agricultural carbon sequestration (Feng, Zhao, and Kling, 2000). However, they differ considerably in practice, particularly regarding permit price uncertainty. Other factors affecting implementation are transaction costs, default of payment, measurement and verification, and existing farm programs.

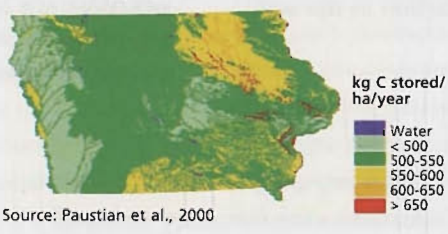
PAYG. Under PAYG, forcing farmers to pay back the full permit price upon carbon release may be difficult, and even infeasible, when farm income is low (which is also when farmers have more incentive to reverse sequestration to boost income from crop production). Facing the likelihood of farmer default, other parties in the private sector may not wish to enforce the payback, leaving the government as the only possible party to transact directly with farmers. The possibility of default may be even higher, given the history of farm programs in the U.S.

If the system is strictly enforced, risk averse farmers may be reluctant to participate given the possibility of higher future prices. Overall, the PAYG system is unlikely to be feasible.

VLC. The VLC system greatly reduces the likelihood of default because for the most part, it is the brokers who will face permit price uncertainty. Given that private brokers have already demonstrated interest in contracting for carbon storage services (Economist), this approach may be quite feasible. The major challenge facing VLC is likely to be transaction and administrative costs: particularly, in auditing brokers who contract with a large number of farmers and offer many kinds of contracts.

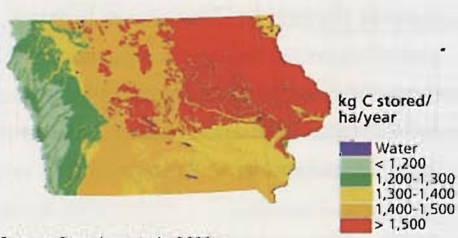
Further, enforcing and managing these contracts may also incur significant transaction costs. To cover these transaction costs, brokers will have to reduce carbon sequestration payments, which in turn will reduce farmer participation.

Figure 2. Increase in Iowa Soil Storage Rates with Conversion of Conventional-Till Corn/Soybeans to No-Till



Source: Paustian et al., 2000

Figure 3. Increase in Iowa Soil Storage Rates with Conservation Reserve Program



Source: Paustian et al., 2000

Alternatively, governments may choose to offer such contracts.

CAA. Compared with PAYG, the CAA system reduces the possibility of farmer default since they only have to pay back the difference between permit prices if the permit price is higher when carbon is released. Unlike VLC, farmers rather brokers face the risk of higher permit prices in the future, and extreme volatility of prices may discourage participation. However, farmers also have the flexibility in this system of leaving the program when permit prices are low. If the accounts are offered as part of a government program, they could be administered in conjunction with existing conservation programs, such as CRP. Thus the institutional setting for CAA already exists, in a sense, likely facilitating its implementation (the other two mechanisms may be amenable to joint implementation as well).

Finally, common to all three systems are the issues of effective monitoring and enforcement, agreement on a baseline for measurement, and potential "leakage" (or substitution of emissions from one location to another). Despite these concerns, there is ample reason to be optimistic that effective market mechanisms or government programs can be devised to include agricultural soils in an effective greenhouse gas policy.

For More Information

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3 systems for carbon sequestration

Pay-As-You-Go (PAYG)

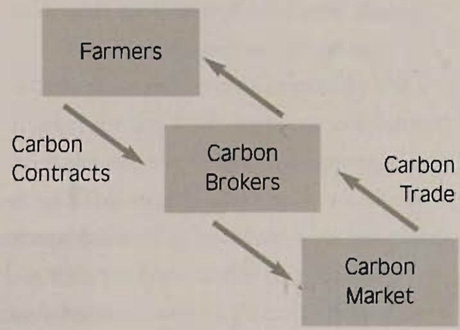
Suppose a farmer would like to enter into a contract to sequester carbon by adopting conservation tillage practices; however, she is not willing to commit to that practice indefinitely, but only for five years. In each year that she practices conservation tillage her land sequesters 1000 metric tons of carbon. Thus, if she were to revert to conventional till in the sixth year, she would release the 5000 tons of carbon she would have accumulated in her soils. We will use this example farmer to explain the operation of the three systems.

Under the PAYG system, the farmer would sell emission credits based on a permanent reduction of carbon. Thus, for the first five years, the farmer could sell 1,000 credits each at the full price of permanent reductions. However, in the sixth year, she would be required to purchase carbon credits from the market at the going price to cover her emissions (5,000 total). For parties who transact with the farmer, there is no complication. They pay full price for the credits they buy, and can treat them the same as if the credits were from emission reductions. Such a system is efficient and easy to understand.

Even though a PAYG system functions similarly to a standard trading system, it could require additional accounting of carbon that is kept in the farmer's land: the farmer's credit balance changes whenever she sequesters or releases carbon and she is paid or charged accordingly. Thus, an agency, whether private or public, must be established to monitor these changes. Such an agency would be needed even in a standard permit trading market. The only difference is that here we will also have sequestration, that is, negative emissions.

Variable Length Contract (VLC)

This system might evolve through independent broker arrangements. Again, the farmer is interested in storing carbon for five years. If a broker buys permits from sink sources and sells them to emitters, the broker must contract with sink sources to achieve a permanent reduction in carbon. The broker could accomplish this by purchasing a contract with the above farmer to adopt conservation tillage for the first five years, and then contracting with another farmer to plant trees beginning in year six for a certain number of years, and so on. In each period, the broker might offer farmers a menu of prices associated with different contract lengths. The institutional structure of this system can be depicted as:



The prices of contracts with different lengths are determined by the market. If there are no arbitrage opportunities in emission and contract trading, the prices will be efficient, and will be fractions of the permanent price depending on the contract lengths.

The carbon broker functions as an aggregator, converting temporary carbon reductions into permanent ones. In addition, brokers aggregate small reductions by individual farmers into large volumes more suited to the trading needs of industrial firms.

Carbon Annuity Account (CAA)

As for the farmer in the other two examples, an annuity account would be opened for her in the first year. In each of the first five years, the value of 1,000 tons of carbon would be deposited into the account. The farmer would collect earnings on this account for these years. However, in the sixth year when the carbon is released, the on-going value of 5,000 tons of carbon would be deducted from the account.

The payment deposited in the annuity account works as a "bond" — with the money in the account, the farmer is discouraged from releasing her stored carbon, and if she releases it, it is guaranteed that she will be able to pay at least partly for the released carbon. Except for this "bond-like" property, the CAA is the same as the PAYG.