Towards Implementing Carbon Markets in Agriculture

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TOWARDS IMPLEMENTING CARBON MARKETS IN AGRICULTURE

With the anticipated release of the Intergovernmental Panel on Climate Change's revised forecast (Revkin) 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. In addition to being a generator of GHG (Schneider and McCarl), agriculture has the potential to sequester (or store) large amounts of carbon and other GHGs in its soil (Lal et al.; The Intergovernmental Panel on Climate Change). The activities that may enhance the storage of carbon in agricultural soils include planting trees, converting from conventional to conservational tillage, adopting improved cropping systems, converting to perennial crops, and restoring the wetlands, among others.

It is estimated that the U.S. cropland's overall potential of C sequestration is 75-208 million metric tons of carbon equivalence per year (MMTC/yr), which, on the average, 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 (Lat et al.). Figure 1 shows the distribution of the 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. estimate that in Iowa, for a corn-soybean rotation, conversion from conventional till to no till could increase carbon storage rates by about 550 kg/ha/yr; see Figure 2; for land enrolled in the Conservation Reserve Program (CRP), the rates are about 1500 kg/ha/yr; see Figure 3. At $20/ton, the total potential revenue that carbon sequestration might bring to Iowans is more than $100 million/yr. Pautsch et al. also estimate that the income potential for Iowa farmers is substantial. Antle et al. provide similar estimates for Montana. They estimate that at $30/ton, carbon sequestration could provide payments worth $13.5 million/yr for 20 years to Montana grain producers who would switch from a crop/fallow to a continuous cropping system.

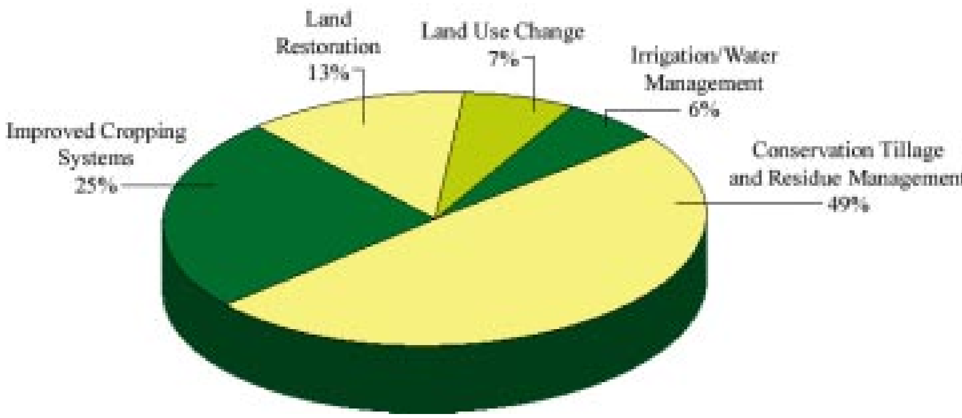


FIGURE 1. Carbon sequestration potential of different improved practices of U.S. cropland

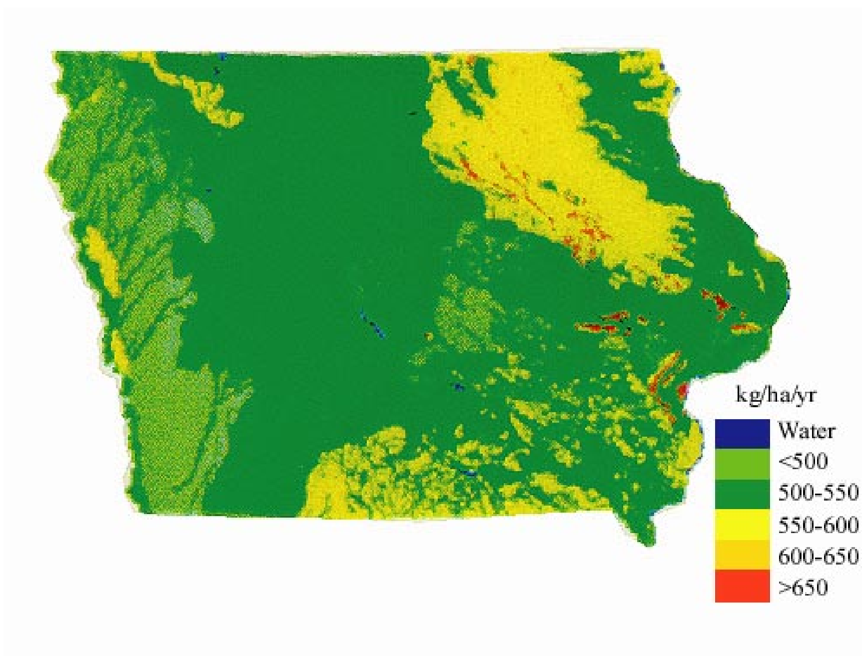


FIGURE 2. Increase in Iowa soil storage rates with conversion of conventional-till corn-soybean to no-till

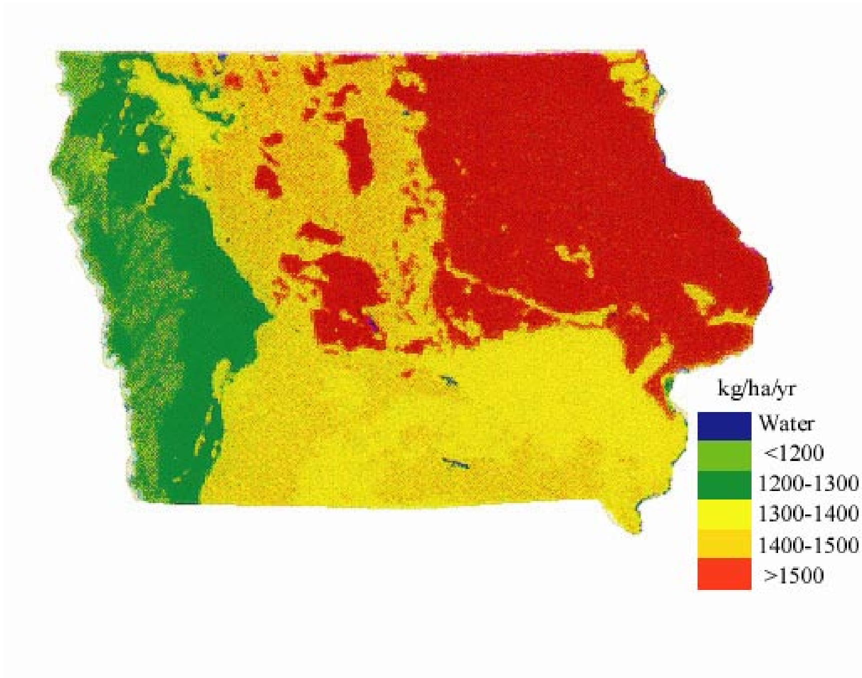


FIGURE 3. Increase in Iowa soil storage rates with Conservation Reserve Program

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

Despite the interest in carbon markets or programs for which agriculture could be rewarded for storing carbon, there are still substantive questions about how such mechanisms could be designed to meet this task and be generally acceptable to the international community. Under the Kyoto Protocol, carbon sequestered through forestry is explicitly allowed, though no role currently exists for agricultural soils. The language of the protocol clearly allows for the future admission of agricultural soil sinks; however, member countries are not likely to ratify its inclusion until key implementation issues are resolved.

One of the most problematic of these issues is the fact that, unlike reductions in emissions, carbon sinks may only temporarily hold 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 the storage of carbon in the soil. For example, switching production practices from conventional to low till may sequester a significant amount of carbon over several years. However, if the farmer reverts to conventional tillage practices, virtually all of the stored carbon will be released immediately.

Mechanisms that Account for the Temporary Nature of Sinks

Agricultural sinks may be intentionally temporary or unintentionally so. For example, it is quite easy to imagine a farmer signing 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, or at least possibly 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.

Although agricultural sinks may be temporary, it is important to note that in most common situations the sinks will have positive value, albeit not as great as those 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 damages.

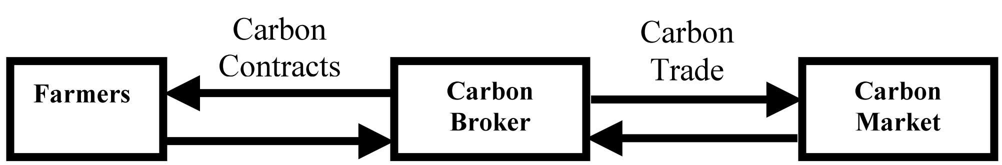
Until policy mechanisms that appropriately incorporate the potentially temporary nature of sinks are developed, it is unlikely that agricultural sequestration will gain widespread acceptance. We introduce and discuss three such mechanisms. These mechanisms could be implemented in the context of either 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 carbon price for one unit of credit is the price associated with one unit of *permanent* carbon reduction.

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.

Pay-As-You-Go (PAYG) System. Under this system, the farmer would sell emission credits based on a permanent reduction of carbon. Thus, for the first five years, the farmer could sell 1000 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 (5000 worth). Such a system is easy to understand and is efficient.

Variable Length Contract (VLC) System. This system might evolve through independent broker arrangements. 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. This could be accomplished by purchasing a contract with one farmer to adopt conservation tillage for the first five years and then contracting with a second 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 is depicted in the following figure.



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.

Carbon Annuity Account (CAA) System. In this system, a sink source receives the full permit price when it starts to store a unit of pollutant. The payment is subsequently put into an annuity account as the principal contribution. The owner can access the *earnings* of the account, but not the principal. The principal's value is subsequently reduced at the on-going permit price when the stored carbon is released. If the sink remains permanent, the sink owner eventually earns all of the interest payments, the discounted present value of which equals the principal itself. The system is parallel to PAYG, and is efficient.

For the above farmer, an annuity account would be opened for her in the first year. In each of the first five years, the value of 1000 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 5000 tons of carbon would be deducted from the account.

Merits of the Mechanisms

With certainty and perfect foresight of future carbon permit prices, each of the three systems provides an economically efficient solution to the non-permanence problem (see Feng, Zhao, and Kling for details). However, they differ considerably in their implementation, particularly with permit price uncertainty. Other factors affecting implementation are transaction costs, default of payment, measurement and verification, and existing farm programs.

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 directly transact with farmers. Then the possibility of default may be even higher, given the history of farm programs in the United States. 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.

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 (*The Economist*), this approach may be quite feasible. The major challenge facing VLC is likely to be transaction costs, particularly in auditing brokers who contract with a large number of farmers and offer long menus of contracts. Further, enforcing and managing these contracts may also incur significant transaction costs. To cover these transaction costs, brokers will have to reduce payments to sequestration, reducing farmer participation. Alternatively, the government may choose to offer such contracts.

Compared with PAYG, the CAA system reduces the possibility of farmer default because farmers only have to pay back the *difference* between permit prices *if* the permit price is higher upon carbon release. Unlike VLC, farmers rather than 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 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 large part, likely facilitating its implementation (though the other 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.

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