Carbon Sequestration, Co-Benefits, and Conservation Programs

Hongli Feng, Catherine L. Kling, and Philip W. Gassman

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Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa 50011-1070
www.card.iastate.edu

Hongli Feng is an assistant scientist at the Center for Agricultural and Rural Development (CARD); Catherine Kling is a professor of economics and head of the Resource and Environmental Policy Division at CARD; Philip Gassman is an assistant scientist at CARD; all at Iowa State University.

For questions or comments about the contents of this paper, please contact Hongli Feng, 560D Heady Hall, Iowa State University, Ames, IA 50011-1070; Ph: 515-294-6307; Fax: 515-294-6336; E-mail: hfeng@iastate.edu.

Abstract

Land use changes to sequester carbon also provide "co-benefits," some of which (for example, water quality) have attracted at least as much attention as carbon storage. The non-separability of these co-benefits presents a challenge for policy design. If carbon markets are employed, then social efficiency will depend on how we take into account co-benefits, that is, externalities, in such markets. If carbon sequestration is incorporated into conservation programs, then the weight given to carbon sequestration relative to its co-benefits will partly shape these programs. Using the Conservation Reserve Program (CRP) as an example, we show that CRP has been sequestering carbon, which was not an intended objective of the program. We also demonstrate that more carbon would have been sequestered had CRP targeted this objective, although the "co-benefits" would have increased or decreased.

Keywords: carbon sequestration, co-benefits, Conservation Reserve Program.

CARBON SEQUESTRATION, CO-BENEFITS, AND CONSERVATION PROGRAMS

Capturing and storing carbon in biomass and soils in the agriculture and forest sector has gained widespread acceptance as a potential greenhouse gas mitigation strategy. Scientists increasingly understand the mechanisms by which various land-use practices can sequester carbon, including the introduction of cover crops on fallow land, the conversion of conventional tillage to conservation tillage, and the retirement of land from active production to a grass cover or trees. However, the policy design for implementing carbon sequestration activities is still being developed, and significant uncertainties remain concerning the cost effectiveness of carbon sequestration relative to other climate change mitigation strategies.

A potentially important plus in the cost-effectiveness ledger is the fact that the storage of carbon in agricultural soils is likely to come with a number of "co-benefits." In particular, carbon sequestration is not separable from other environmental effects of a given land-use practice. For example, the introduction of cover crops or the conversion to conservation tillage from conventional tillage also reduces soil erosion, in addition to sequestering carbon. The list of potential co-benefits is large and includes wildlife habitat, water quality, and landscape aesthetics.[1]

A second key feature of carbon sequestration is its nonpoint source characteristic. The amount of carbon sequestered in a field or region is costly to measure and monitor and protocols for doing so are still being developed, making it difficult to base any policies directly on environmental performance (see Mooney et al. 2004 for a discussion on the costs of measuring soil carbon credits). In the near term, carbon sequestration policies are likely to base payments on land-use practices or other easy indicators of carbon-sequestering activities.

The issue of co-benefits from sequestration activity has received relatively little attention with some important exceptions. Plantinga and Wu (2003) estimated the reduc-

tions in agricultural externalities from an afforestation program that encouraged the conversion of agricultural land to forest in Wisconsin. Using existing benefit estimates, they showed that the value of reduced soil erosion and some benefits from enhanced wildlife habitat are on the same order of magnitude as the costs of the carbon sequestration policy. Matthews, O'Connor, and Plantinga (2002) also found that carbon sequestration through afforestation has significant impacts on biodiversity and that the impacts can differ by region. McCarl and Schneider (2001) found reduced levels of erosion, phosphorous, and nitrogen pollution from traditional cropland as carbon prices increase. Greenhalgh and Sauer (2003) and Pattanayak et al. (2002) showed that the water quality co-benefit of carbon sequestration is significant.

Policy Design Issues When Co-Benefits Are Considered

The co-benefit aspect of carbon sequestration and its nonpoint source nature have important implications for policy design. Two policy environments have been discussed by economists: carbon trading in a well-functioning carbon market, and some type of green payment program akin to the Conservation Reserve Program (CRP) or the newly initiated Conservation Security Program (CSP). Explicit consideration of the co-benefits of carbon sequestration in the agricultural and forest sector will need to be treated differently depending on whether carbon markets are the primary driver of sequestration activities or whether a green payment policy is pursued. In the context of carbon markets, co-benefits are externalities. To achieve socially efficient trades, we need to determine who will be responsible for (or benefit from) the non-carbon effects associated with sequestration activities. On the other hand, if we place carbon sequestration in the context of agri-environmental policies and consider it as just one of the multiple benefits from conservation practices, then a different set of issues arises, including determining which benefits are most important; which management practices should be encouraged; which geographical areas should be targeted; and whether costs, benefits, or some other criteria should be used to direct the allocation of funding.

A situation in which both green payment programs and carbon markets operate simultaneously adds complications. Green payment programs would need to be designed to consider interactions between their payments and potential payments from a carbon

market. For instance, if recipients of green payments are also eligible to sell carbon credits in a market, then practices that yield high levels of carbon sequestration relative to other environmental benefits will be particularly attractive to land owners (all else equal), potentially resulting in inefficient land-use decisions. If recipients are not eligible for both incentives, then the carbon market will act as competition for land in the green payment program, with implications for the cost of the program. The issue of coordination between these two policy approaches is already on the horizon, as some conservation programs have been sequestering carbon for many years, and nascent carbon markets are emerging (see Butt and McCarl 2004). The CRP program, with its annual budget of $1.6 billion, has been shown to have large carbon-sequestering potential. This is so despite the fact that carbon sequestration was added only in recent signups as an environmental benefit in the evaluation of the applications to the program.

Co-benefits in the Upper Mississippi River Basin

Given the present existence of green payment programs (e.g., the CRP as well as the new CSP), the remainder of this paper explores the co-benefits of carbon sequestration in the context of subsidy policies. The example developed here compares carbon sequestration, erosion reduction, and nutrient reduction benefits across several different methods that could be used to implement the CRP program in the Upper Mississippi River Basin (UMRB). Similar methodologies are used in Kurkalova, Kling, and Zhao 2004, although that study explores the adoption of conservation tillage in the region.

The UMRB is a highly fertile agricultural region covering 189,000 square miles in seven states in the central United States, with 67 percent of the area being either cropland or pasture land. The potential for significant co-benefits from carbon sequestration in the region is large given that it contains more than 1,200 stream segments and lakes that appear on the U.S. Environmental Protection Agency's listing of impaired waterways. The region contained 3,363,000 acres covered under the CRP in 1997, with a total annual payment of about $277,500,000 (estimated using the rental payment information of the eighteenth signup of the CRP). Average CRP rental rates in Iowa and Illinois are above $120 per acre, while Missouri and Wisconsin have the lowest rental rates, with an aver-

age of about $60 per acre. Minnesota falls somewhere in between, with an average rental rate of $86 per acre.

To estimate the environmental benefits of converting land to CRP, we use the Environmental Policy Integrated Climate (EPIC) model, version 3060.[2] EPIC simulations were run for each point in the Natural Resource Inventory database in the region (over 40,000 points in total) for 10 years, the duration for most CRP contracts. Carbon sequestration is measured as the annual average of the total accumulated carbon, that is, the difference of the total soil carbon pool at the beginning and at the end of the simulation period. Other environmental benefits (reduction of water erosion and nitrogen runoff) are the average of the annual measurement, where CRP land is compared to intensive farming practices typical for the region. For the whole UMRB, the annual average carbon sequestration rate for land converted to CRP is 0.487 tons per acre. The first row of Table 1 provides an estimate of three environmental benefits that result from the existing CRP program.

We next examine how sensitive these environmental results are to different ways of implementing the policy. Specifically, we consider how much carbon would have been sequestered by the CRP had the program been implemented primarily as (*a*) a carbon sequestration policy or (*b*) an erosion-reduction policy. Information on rental rates is used to analyze two different scenarios with different targeting strategies, so that parcels with the highest targeted benefit are chosen until the program funding (the total expenditure for the actual CRP program) is exhausted.

Two results are evident in Table 1. First, if the CRP had been targeted specifically at carbon (row 2), then considerably more carbon would have been sequestered relative to the actual CRP (row 1). More reduction in nitrogen runoff would also have been

TABLE 1. Total acres and annual change for some environmental indicators as a result of land retirement in the Upper Mississippi River Basin

Policy Scenarios	Carbon Sequestration (tons)	Erosion Reduction (tons)	N Runoff Reduction (pounds)	Acres Enrolled (acres)
1. Actual CRP	1,054,000	15,293,000	4,654,000	3,122,000
2. Targeting carbon	4,141,000	4,699,000	6,365,000	3,926,000
3. Targeting erosion	988,000	43,744,000	9,399,000	3,972,000

achieved, although the erosion-reduction benefit would have fallen relative to the existing program. Second, if the CRP had been targeted specifically at erosion (row 3), then significantly more erosion and runoff benefit would have been achieved while carbon sequestration levels would have declined slightly. Different regions benefit from the program depending on which policies are used to implement the program. Figure 1 indicates that the actual CRP acres are about evenly spread around the region. When carbon is targeted, selected land concentrates in southern Minnesota, eastern Wisconsin, and parts of Iowa (Figure 2), and when erosion is targeted, selected land concentrates along the Mississippi River (Figure 3).

To gain more perspective on the total amount of carbon sequestered, suppose there is a carbon market with various prices. At a carbon price of $10 per ton, a relatively low value used in the literature, the value of the carbon sequestered by the actual CRP is about $10 million dollars. This is far less than the actual program costs in the region, implying that at this price the carbon market would not be able to induce the change in land-use practice that the actual CRP program induced. On the other hand, if the carbon
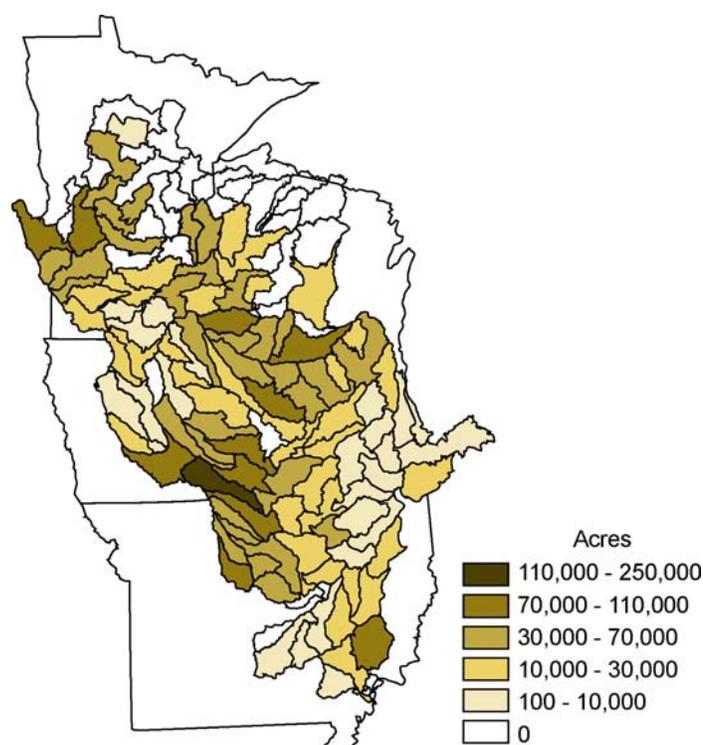
FIGURE 1. Area selected—the actual CRP program
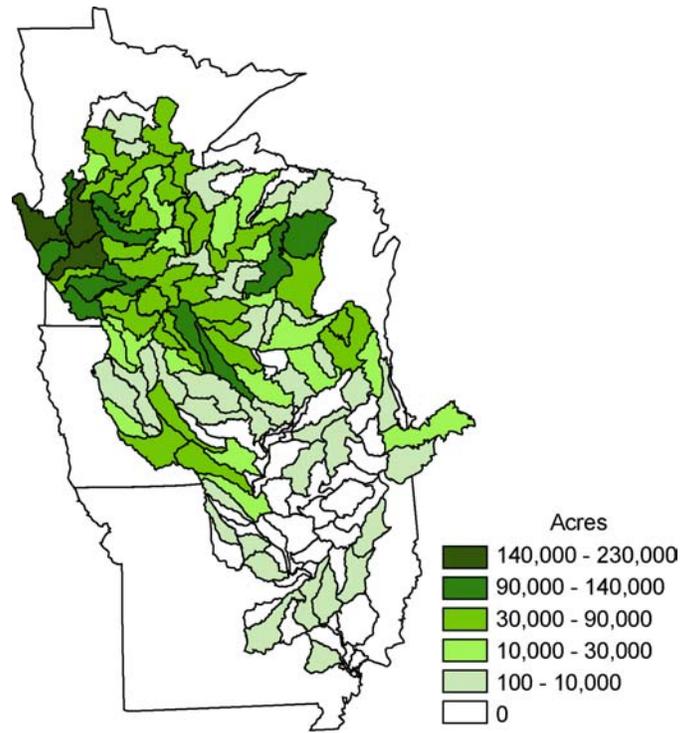
FIGURE 2. Area selected—target carbon
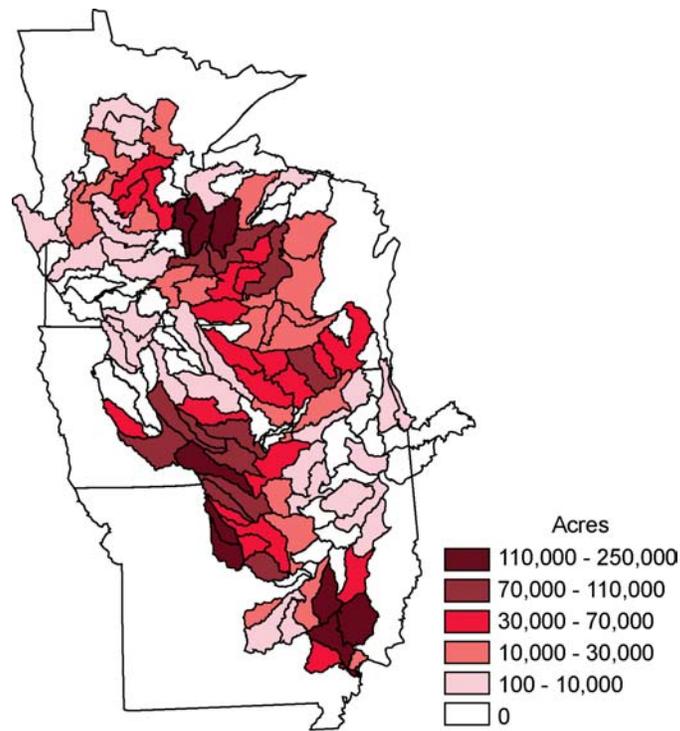
FIGURE 3. Area selected—target erosion

price were over $100 per ton, the value of the carbon sequestered by the actual CRP would be about one-third of the program costs. However, if parcels with the best carbon potential participate in the market, as theory would predict, then the total value would be above $300 million, which exceeds the program costs. In this case, the carbon market could replace the actual CRP in the sense of obtaining the same level of carbon sequestration. However, other environmental benefits might be reduced. This perspective illustrates the complication of policy design for carbon sequestration when both green payment programs and carbon markets coexist.

Conclusions

Given that carbon sequestration cannot be separated from many important co-benefits, policies focused on increasing carbon storage in agriculture and forest lands need to carefully consider the consequences of carbon sequestration programs on multiple environmental benefits. To demonstrate the importance of this point, this paper presents results from an analysis of a large and potentially rich source of carbon sequestration—the UMRB—as well as co-benefits. Our results suggest that had the CRP been designed to achieve the greatest carbon for the budget allocated, the land parcels chosen for inclusion would be significantly different than either the actual CRP or a different kind of program that instead targets soil erosion.

Numerous design challenges remain in order for conservation policies to elicit socially optimal levels of carbon sequestration, nutrient loads, soil erosion, biodiversity, and other landscape amenities. In addition to considering co-benefits, interactions among incentives from competing conservation programs (e.g., the CRP and the CSP) and the introduction of carbon markets will also present challenges to policy design. Finally, we note that the results presented here are based on field-level simulations for a large region and that there is ongoing development of EPIC, other environmental models, and economic models of costs. As the models evolve, the results of analyses such as the one undertaken here may change as well.

Endnotes

1. There may also be "dis-benefits" such as increased pesticide use with some carbon-sequestering practices.

2. Additional information concerning EPIC can be found in Gassman et al. 2004. Details concerning model assumptions and data can be found in Feng et al. 2004.

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