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Agricultural producers may be able to benefit from providing carbon sequestration services to private markets or government programs over the medium term. Agricultural soils provide a potential sink for carbon, and producers can provide carbon sequestration services by using management practices that store carbon in the soil. Markets for carbon credits are emerging in Europe and in North America, and some of the early trades involve agricultural producers selling carbon sequestration services. In addition, the U.S. government may implement agricultural programs to meet goals for carbon emissions by paying producers to sequester carbon.

These developments are a response to international concern about global warming and the growing scientific evidence that emissions of heat-trapping or greenhouse gases (GHGs) have resulted in climate change. Carbon dioxide is the most important GHG of the six included in the Kyoto Protocol, accounting for 80% of the GHGs emitted by developed countries. Official sources estimate that the United States emitted 1,883 million metric tons carbon equivalent (MMTCE) in 2001 (U.S. Department of Energy 2002a). This article discusses policies affecting the demand for carbon sequestration in agriculture. Agricultural sequestration services will have to compete with other providers

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of carbon credits, and thus the demand for agricultural sequestration services depends on the demand for carbon credits generally. The intertwined question of how these policies and markets will affect the development of government programs for carbon sequestration in agriculture is also examined.

The United Nations Framework Convention on Climate Change and the Kyoto Protocol

International concern about increased levels of carbon dioxide and other GHGs in the earth's atmosphere led to establishing the Intergovernmental Panel on Climate Change in 1988. The panel concluded that human activities increased emissions of GHGs and caused climate change. While acknowledging a degree of scientific uncertainty, the United Nations Framework Convention on Climate Change (UNFCCC) states that "where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures [to reduce GHG emissions]" (Climate Change Secretariat). Having been ratified by 175 nations, including the United States, the United Nations Convention took effect in 1994. The convention's primary objective is to reduce atmospheric GHG concentrations to levels that would prevent dangerous interference with the climate system. All parties to the UNFCCC agreed to prepare and update national climate change mitigation and adaptation programs, including measures to reduce emissions and enhance sinks for carbon; promote the use of climate-friendly technology; undertake research on climate change and its mitigation; and compile and submit a national inventory of GHG emissions.

In addition, Annex I parties (41 industrialized countries and economies in transition [EIT]) agreed to the non-legally binding aim of reducing emissions to 1990 levels by the year 2000. Annex II parties (industrialized minus EITs) further agreed to financially assist other parties in acquiring appropriate technology. Annex I parties are encouraged to undertake projects in other countries to reduce emissions or increase removal of GHGs.

Since the U.N. Framework took effect in 1994, stronger scientific evidence on the existence of climate change, as well as concern that emissions were continuing to rise, prompted the negotiation of the Kyoto Protocol, which concluded in December 1997. The key provision of the protocol requires Annex I parties (developed countries) to collectively reduce emissions of GHGs to a level 5% below the 1990 level by the first commitment period of 2008 to 2012. The protocol also calls for establishing policies to reduce emissions, including phasing out subsidies for energy-intensive technologies, creating regulatory standards that encourage adoption of alternative energy sources, taxing emissions, reducing emissions from transport systems, and controlling methane emissions through innovative waste management.

The Kyoto Protocol allows Annex I countries to meet their commitments at least cost within some constraints. They can receive credit for implementing projects that reduce emissions or remove carbon from the air in other countries, and they can trade credits with other Annex I parties, subject to conditions.

The issue of establishing credits for forestry and agriculture as carbon sinks was hotly debated during the negotiations. It is difficult to verify the amount of carbon

sequestered by agriculture over time. Nevertheless, guidelines for carbon sequestration were agreed to in the 2001 Marrakesh accords, which provide rules for land use, land-use change, and forestry (UNFCCC 2002a). Revegetation and improved management of cropland and grazing land were recognized as carbon sinks, and parties can receive credits for carbon sequestered in excess of 1990 levels. Scientific bodies supporting the Kyoto Protocol continue to work on protocols to verify emissions removals achieved by these activities.

The Kyoto Protocol will enter into force when it has been ratified by 55 Annex I governments representing 55% of the total Annex I 1990 carbon dioxide emissions (UNFCCC 2002b). Currently, 101 countries representing 43.9% of emissions have ratified the protocol, and it is expected that it will enter into force in 2003 with Russia's anticipated signing. Countries that have not ratified the Kyoto Protocol, including Australia and the United States, will continue to be bound by their commitments under the UNFCCC.

Only parties that have ratified the protocol and have met methodological and reporting requirements may engage in emissions trading that counts toward meeting Kyoto Protocol requirements. Annex I parties can purchase credits only from other ratified Annex I parties. Because they have not ratified the Kyoto Protocol, the United States and Australia cannot sell emissions or removal credits to other Annex I parties. This means that the carbon trading market will be fractured into a market for sellers who have ratified the protocol and sellers who have not. International demand is likely to be severely limited for carbon credits from sellers who have not ratified the Kyoto Protocol,

as the only buyers would be countries that have not ratified and thus are not under any binding commitments to reduce emissions.

The U.S. Response to Climate Change and the Kyoto Protocol

The Clinton administration negotiated the Kyoto Protocol and the Bush administration has declined to ratify it. President Bush's public remarks argue against both the form of the Kyoto Protocol and the scientific evidence behind it. In 2001, he stated that the emissions targets established by the Kyoto Protocol "were arbitrary and not based on science" and further claimed that "no one can say with any certainty what constitutes a dangerous level of warming, and therefore what level must be avoided" (O'Neill and Oppenheimer, p. 1971). In addition, President Bush has been dissatisfied with the division of responsibility between the developed and the developing countries (White House 2001).

The Bush administration has proposed a voluntary program of reducing GHG "intensity" by 18% in the next ten years (U.S. Department of State). GHG intensity is defined as the ratio of GHG emissions to economic output. The administration proposes to lower the current GHG intensity of 183 MTCE per million dollars of gross domestic product to 151 MTCE per million dollars by 2012 through voluntary and incentive-based measures. A key part of the administration's plan is tax incentives for the development of renewable energy, hybrid and fuel cell-powered vehicles, co-generation and landfill gas, and other new technologies. In response to the administration's plan, some businesses have developed their own voluntary initiatives to reduce GHG emissions (White House 2003).

A key criticism of the administration plan is that it allows U.S. total emissions to continue increasing on its current trend. Total U.S. GHG emissions increased from 1,671 MMTCE in 1990 to 1,907 MMTCE in 2000, a 14% increase. Under the administration's plan, 2012 emissions (2,155 MMTCE) would be 30% above 1990 levels (Pew Center on Global Change). If the United States had ratified the Kyoto Protocol, it would be required to reduce its emissions to 93% of 1990 levels by 2008–2012. The Pew Center on Global Climate Change notes that GHG intensity fell by 21% in the 1980s and 16% in the 1990s, so that at best the Bush plan will result in only very slight improvements over existing trends.

The Bush administration proposal mandates improvements to the current federal registry of GHG emissions. The goal of registry improvements is to ensure that voluntary actions taken by industry to reduce GHG emissions will be rewarded in the future with transferable credits for emission reductions. Currently, few businesses participate in the registry, because there is no third-party verification of reductions for buyers of carbon credits (Chartier). Registry improvements are expected to be slow due to concerns over the legality of binding future Congresses to the current administration plan to grant transferable credits.

The administration's failure to adopt binding national emissions limits and to ratify the Kyoto Protocol may be perceived by U.S. industry as a signal that Bush does not consider climate change to be a serious national problem that requires international cooperation. While some firms may voluntarily reduce emissions to take advantage of new technology or to enhance their reputations, other firms will not find incentives strong

enough to bear the cost. The United States failed to meet the voluntary goals agreed to in the UNFCCC. The United States is using emissions caps and trading programs to address other pollution problems. The U.S. national program to reduce acid rain includes emissions limits and trading and has been widely considered to be successful in meeting environmental goals in a cost-effective manner (USEPA 2002a). Discontented with current Bush administration climate policy, Senators McCain and Lieberman have introduced a bill to Congress to mandate emissions reductions and to create an emissions trading market.

Because GHG emissions emanate from all over the globe, it is widely recognized as an international problem requiring broad-based international solutions (Antle). The United States has ratified other multilateral environmental agreements to reduce international emissions of pollutants. An example in point is the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. This treaty has been more successful than anticipated in promoting technological solutions, in achieving reduction goals, and in productively involving developing countries in the multilateral effort (UNEP; USEPA 2002b). The lack of a credible national plan for reducing GHG emissions has motivated state governments to fill the void, creating a disjuncture between national and state policies.

U.S. State Policies on GHG Mitigation

Many state governments have undertaken policies to reduce GHG emissions (Rabe). State regulations and programs frequently embed GHG mitigation in a broader set of goals that include economic development, energy independence, reduction of air

pollution, and prevention of urban sprawl. States have enacted legislation designed to reduce emissions from older power plants (Massachusetts), new power plants (Oregon), and cars and trucks (California). The New England states and five Canadian provinces have committed to the development of a common framework for achieving GHG reductions. Thirty-eight states are implementing registries with various requirements and formats to record emissions and reductions by entities within state boundaries (USEPA 2002c). California's registry accepts reports from businesses, nonprofit organizations, municipalities, and government agencies and has established the third-party verification procedures lacking in the federal registry. These state registries provide the information necessary to establish emissions baselines, the foundation for offset programs. State registries have been promoted by the federal government as the first step in reducing GHG emissions.

In the past, state environmental programs have often served as prototypes for subsequent federal programs. However, in this case, the federal government has not undertaken major responsibility for solving a problem best addressed at the national level and instead is encouraging state governments, businesses, and nongovernmental organizations to address the problem. The result is a patchwork of registries and incentives for emissions reductions that is detrimental to the development of an efficient market for carbon trading.

The Market for Carbon Trading

The strength of the market for carbon credits will determine the demand for agricultural sequestration services. Market analysts state that the international market for carbon

trading is expanding rapidly; in 2002 the World Bank estimated that trading would triple over the following year to over 67 million tons and that trade will reach the multibillion-dollar mark in seven years (Reuters). Forty U.S. companies are developing the Chicago Climate Exchange, which will begin trading emissions credits for all six GHGs in 2003 for the U.S. market and will expand to include international participants in 2004 (Chicago Climate Exchange). A single reliable source of market information has not yet been established, so estimates of the current size of the carbon market vary, as trading is occurring both through brokerage firms and directly between buyers and sellers.

In nations that have ratified the Kyoto Protocol, firms are trading with the expectation that the demand for carbon credits will increase with the implementation of the protocol and its binding emissions limits. Potential buyers, sellers, and intermediaries want to “learn by doing” and become established in the market. Buyers of carbon credits are mostly industries that expect to be regulated under the Kyoto Protocol or that are currently regulated, such as in the United Kingdom. For example, energy companies that emit GHGs can purchase credits from a renewable energy business, such as a wind-power generator of electricity, whose activities can create emissions offsets. When the Kyoto Protocol is in force, regulated firms could buy credits from other firms holding credits or from firms that can create offsets.

Currently, prices for carbon credits are below their social opportunity cost due to uncertainty over future policies and the development of the market (Grubb). In the United States, firms may be motivated to purchase carbon credits at low prices now that would be worth more in the future when binding emissions reductions were enacted. Another

motivation to purchase credits is to enhance a firm's reputation as a good environmental citizen. Environmental groups and the Bush administration have capitalized on this motivation by developing programs that publicize the actions of these firms through the media and Internet. Finally, some multinational firms recognize that their facilities will have to meet limits in countries that have ratified the Kyoto Protocol, and many anticipate that limits will eventually be enacted in the United States (Ball).

The Market for Agricultural Sequestration

Purchases of agricultural sequestration services are rare at this time, and market information is limited. A few pilot purchases of agricultural sequestration services are occurring (Environmental Defense). An indication of the relative scarcity of agricultural sequestration projects can be gained from the Environmental Protection Agency registry of voluntary measures to reduce, avoid, or sequester greenhouse gas emissions. Of a total of 369 sequestration projects, 362 involved forestry and 2 involved agricultural sequestration (U.S. Department of Energy 2002b). These projects were not reported as trades, and this number is referenced simply to emphasize that agricultural sequestration projects and trades are rare at this time.

The most significant factors constraining demand in the U.S. carbon market are the lack of binding emissions reduction targets and timetables and a lack of clarity over future U.S. GHG policy. In addition, the nascent market for GHGs has high transactions costs due to poorly defined product terms. Transactions require detailed contracts that are relatively expensive to produce. Carbon market traders have called for a market regulatory body and regulations to further define product characteristics. The markets for

sulfur dioxide (SO₂) and nitrogen oxide (NO_x) could provide a template for carbon contracts (Emissions Marketing Association).

Agricultural sequestration services have some unique characteristics that could increase the difficulty of creating widely accepted commodity characteristics. For example, the amount of carbon sequestered by a prescribed set of management practices depends on the history of the land and the soil type, and carbon sequestered in agricultural lands may be released when agricultural practices are changed. These characteristics make it more difficult to design contracts, as discussed by Antle et al. (2003).

U.S. Government Agricultural Programs for Carbon Sequestration

The Bush administration is receptive to the concept of programs that would pay producers for agricultural sequestration of carbon. In his climate change initiative, President Bush directed the Secretary of Agriculture to provide recommendations on further targeted incentives for agricultural sequestration of GHGs (White House 2002). The Farm Security and Rural Investment Act of 2002 provided increased funding to conservation programs overall and specifically funded carbon sequestration research, development, and pilot projects (U.S. Public Law 107-717). President Bush has also charged the Secretary of Agriculture with developing accounting rules and guidelines for such projects in an effort to improve the Department of Energy's Voluntary Greenhouse Reporting Program. Congressional support for agricultural sequestration is evidenced by the numerous bills, approximately 25, introduced to Congress in support of carbon sequestration in agriculture and forestry (Hayes and Gertler).

Agricultural carbon sequestration programs appeal to the current administration for a number of reasons. First, the proposed programs are voluntary, in line with the administration's stance against mandatory programs. Second, agricultural sequestration of carbon produces environmental benefits in addition to reducing GHGs, including reduced soil erosion and improved soil quality. Third, the new programs could likely be designed to be compatible with U.S. commitments under the Uruguay Round Agreement on Agriculture, as these programs would meet the requirements of programs that are exempt from limits. The voluntary nature of these programs, the public support for environmental programs, and the continuing pressure to support farm income all combine to make expansion and adaptation of current environmental programs a likely vehicle for achieving administration climate policy goals.

The agricultural sector sequestered an estimated 17 MMTCE per year between 1982 and 1997 (Sperow, Eve, and Paustian) through decreased tilling intensity and other management changes. The Conservation Reserve Program, with a 1997 baseline of 13.2 million hectares of land under protective vegetative cover, is estimated to account for 4.5 MMTCE per year of the 17 MMTCE per year total. Sperow, Eve, and Paustian estimate that conversion of highly erodible land to CRP could sequester an additional 10.5 MMTCE per year over a period of fifteen years. Adopting no-till practices on all farmland that is now annually cropped would increase soil sequestration by 47 MMTCE per year, and eliminating summer fallow would remove an additional 20 MMTCE per year. The total sequestration potential (setting aside overlapping management options on

the same land) is estimated to be 83 MMTCE per year. This is equivalent to approximately 5% of total 1999 U.S. carbon emissions.

The rules for potential programs, and the combination of existing and new programs used by the administration, depend on continuation of national voluntary and non-binding reduction goals. Under this scenario, there is less need for careful verification of producer compliance and estimation of the amount of carbon actually sequestered. If the United States should ratify the Kyoto Protocol, it will need to adopt international standards being developed for verification and monitoring.

Nebraska, Illinois, North Dakota, Oklahoma, and Wyoming have all passed legislation creating advisory panels on the potential for agricultural sequestration of carbon, with accompanying research and pilot projects (Rabe, p. 7). In Montana, the National Carbon Offset Coalition (a combination of federal, state, and business interests) has pilot projects that offer producers payment through both the private market and government programs. Ted Dodge, Project Development Director of the National Carbon Offset Coalition, has stated that bundling these environmental services may make it possible for producers to offer carbon sequestration services at a price that is attractive to potential buyers (personal communication, January 15, 2003). Research on agricultural carbon sequestration in Montana shows producers could be competitive suppliers of carbon sequestration services (Antle et al. 2002).

Conclusions

U.S. markets for agricultural carbon sequestration services will likely be small unless there is a change in U.S. federal climate-change policy. The Bush administration's

climate-change policy establishes emissions reductions at roughly the same pace that they have occurred over the past twenty years due to technological advances. Current U.S. policy is likely to keep demand for carbon credits weak in the United States and given that the United States cannot export carbon credits to entities in countries that have ratified the Kyoto Protocol, international demand for U.S. carbon credits will remain weak as well. As a result, there is little impetus to overcome the verification and measurement challenges the market would require for agricultural sequestration services. State programs are strengthening demand for carbon credits, but at the cost of complying with a myriad of requirements for business that vary by state. The development of the carbon market would be facilitated by the emergence of a seamless market with one set of rules for those demanding and supplying carbon credits. Market demand for agricultural sequestration services is likely to remain weak, however, government agricultural programs may be a source of demand for agricultural sequestration services.

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