Abstract

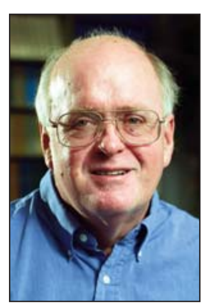
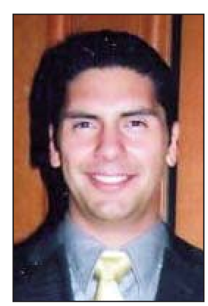
Concerns regarding climate changes due to human activities have largely increased in the past few years. Scientists believe that atmospheric build-up of greenhouse gas (GHG) lead to climate change. The agricultural industry could play a role in the reduction of atmospheric GHGs by sequestering carbon through crop production, rangeland and afforestation offsets. However, there is a limited economic opportunity for landowners to participate in the carbon market as carbon prices have ranged over the years between $2 to $5 per tonne and currently is around $6 leading to returns on the order of $1-5 per acre.

Carbon Sequestration: a Potential Source of Income for Farmers

By Luis A. Ribera, Bruce A. McCarl and Joaquín Zenteno

Concerns regarding climate changes due to human activities have largely increased in the past few years. Many scientists believe that atmospheric build-up of greenhouse gas[1] (GHG) concentrations is causing the climate to change (IPCC, 2007a,b). Furthermore, a large number of scientists assert that continuing levels of GHG emissions will lead to substantial future climate change. Carbon dioxide is the largest of the GHGs in both emissions and concentration (Butt and McCarl, 2005, IPCC, 2007c). Reducing net carbon dioxide emissions to the atmosphere is increasingly being considered as a way of addressing the climate change problem.

International efforts to stabilize the atmospheric concentration of GHGs resulted in a 1997 treaty, the Kyoto Protocol, which was developed with the involvement of over 160 countries, including the U.S. (Butt and McCarl, 2005). In the Kyoto Protocol, the developed countries (like the U.S., U.K. and Canada) agreed to limit their GHG emissions, rolling back to below the levels emitted in 1990. U.S. emissions are about six billion metric tons (tonnes) of carbon dioxide plus about 1 million more carbon dioxide-equivalent (CO_2e) in other gasses. Within the Kyoto Protocol, the U.S. emissions were to be reduced to seven percent below 1990 levels by 2008-2012, which given projected emissions growth would have required scaling back emissions by 30 to 40 percent of what would have occurred in the 2008-2012 time period or 2.1 to 2.8 billion tonnes of CO_2e.

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In 2002, the U.S. stated it would not sign the Kyoto Protocol, but has subsequently stated a domestic policy goal of an 18 percent reduction in GHG emissions per dollar of gross domestic product by 2010, and then an April 2008 national goal of stopping the growth of U.S. greenhouse gas emissions by 2025. Moreover, the 2002 administration plan did not greatly encourage net emission reductions and set a low emissions reduction limit (about 1/6th of the Kyoto obligations – as reviewed in Butt and McCarl, 2005). In addition, the promised emission reductions in both the 2002 and 2008 goals are voluntary. Hence, there is no widespread policy stimulus that will create a significant value for GHG offsets. Nevertheless, there is an international and a small domestic voluntary carbon market.

Why are there carbon markets?

When GHG emissions are limited, policy approaches like that used in the Kyoto Protocol or the recently proposed Lieberman-Warner bill allow emitters to either reduce emissions themselves or to pay for someone else to reduce emissions. This is the origin of a so-called carbon market, which is a market in which reductions of carbon dioxide or other GHG emissions can be bought and sold. The market will exist as long as someone other than large emitters reduce net emissions cheaper than emitters themselves could have.

Who might be the participants in the carbon market?

Markets consist of buyers and sellers. A buyer of carbon offsets[2] would be an entity needing to reduce or offset emissions. For example, a power plant facing an emission cap might be looking for ways to offset emissions that are over and above certain limits (Butt and McCarl, 2004). The objective of a buyer would be to acquire offset credits cheaper than the cost to alter operations to reduce their emissions. Therefore, the largest buyers of carbon offsets are likely to be the largest emitters, like power plants, transportation and industry as a whole (Note that EPA estimates that more than 80 percent of current emissions come from coal and petroleum combustion in about equal proportions with the agricultural share being small).

Potential carbon offset sellers come from various sources. A group of GHG emitters may find they can cheaply change their operations so as to reduce GHG emissions for example reducing fuel consumption, switching to alternative fuels (e.g., from coal to natural gas or bioenergy), altering manure management or reducing fertilization (Butt and McCarl, 2004). In addition, so-called sequestration activities may be undertaken where rather than emitting GHGs, they are to capture and store. One sequestration possibility employs biological sequestration through the characteristics of plants. Such sequestration possibilities may offer market participation possibilities for agriculture.

There are several agricultural forms of biological sequestration that may be pursued, such as changes in tillage practices, crop rotations, land conversion to grasslands and afforestation. Agriculturalists may also reduce emissions through alterations in livestock herd size, livestock feeding, manure management, crop fertilization and biofuel feedstock production, among others (McCarl and Schneider, 2001). However, such activities can be costly; there must be an economic incentive for producers to make changes in production practices to sequester carbon or reduce emissions. Namely, the market price of GHG offsets must be high enough to motivate potential suppliers to change current production practices.

Status of the U.S. GHG Market

The ability of farmers to enter a GHG market depends heavily on the existence of the market and in turn on the policies that the government sets in place to limit or reduce GHG emissions plus allow market participation. As previously mentioned, the U.S. government already has a program for GHG emission reduction that is on a voluntary basis, and therefore has not stimulated a wide spread national market. There are other initiatives at the state or private industry levels to reduce GHG emissions. For example, 10 northeastern states, including New York, Maine and Maryland among others, have joined to create the first mandatory carbon cap-and-trade program[3] in the U.S., while California is in the process of setting up such a market. The northeastern market aims to reduce emissions from power plants by 10 percent in 10 years (Fairfield, 2007). Moreover, in October 2006, Morgan Stanley announced it would invest $3 billion in the carbon market over the next five years, the largest single investment to date (Lavelle, 2007). Also, there is an experimental voluntary market called Chicago Climate Exchange (CCX) where firms are voluntarily buying and selling GHG offsets.

The current price for carbon offsets in the U.S. is around $6 per tonne (price for a metric ton or 2,204 pounds of carbon dioxide equivalent offset), while in Europe the carbon offset price is around $35 per tonne, a much higher level than in the U.S. due to more strict emission regulations (CCX, 2008). However, the U.S. domestic price of carbon offsets will likely increase if tighter emissions controls are implemented. For example, Edmonds et al. (1998) estimated a cost as high as $250 per tonne of carbon for the U.S. if it acted to meet its Kyoto Protocol target for reducing emissions. With international trading of carbon offsets, however, the cost was found to fall to around $25 per tonne of carbon. Estimates from Edmonds et al. are based on an overall GHG emissions reduction, including agriculture, fuel substitution and energy production/consumption.

On April 2, 2007, the U.S. Supreme Court ruled on the Massachusetts v. Environmental Protection Agency (EPA) case that the federal government, through the EPA, has the authority to regulate the carbon dioxide and other GHG produced by motor vehicles. If EPA decides to regulate GHG emissions, it could increase the demand for carbon offsets, therefore supporting a probable increase in price. Moreover, the members of the Intergovernmental Panel on Climate Change (IPCC) recently won the Nobel Peace Prize for their work on climate change, demonstrating an increased awareness and interest on the topic. These developments are creating more public and industry-wide awareness of the potential problems of climate change associated with GHG emissions, and has also contributed to increased interest in global emissions reductions. In the U.S., suppliers of GHG offsets are able to sell their offsets through direct contracts with buyers, or sell their offsets through the CCX. An example of selling GHG offsets through direct contract is the funding of planting over 150,000 trees by the Houston-based energy company, Reliant Energy, in an effort to capture an estimated 215 tonnes of carbon dioxide from the atmosphere, generating "carbon credits" that will be retained by Reliant (http://www.ewire.com/display.cfm/Wire_ID/1557).

The CCX route merits discussion. The CCX was launched in 2003 and is a trading operation that is based on a voluntary, but legally binding, association of a number of emitters and offset suppliers. The commodity traded at the CCX is the Carbon Financial Instrument (CFI), each of which represents 100 tonnes of CO_2e. The volume traded on the CCX in the first quarter of 2008 was about 25 million tonnes of CO_2e or annually around 100 million tonnes. Although, CO_2e traded on the CCX has been increasing since it was launched, total amount traded in the U.S. represents less than five percent of a full Kyoto Protocol set of trades.

The CCX has set up guidelines for participation in a carbon sequestration program through crop production, rangeland management and/or afforestation. However, one of the most restrictive requirements for agriculture to participate in the CCX market would be that an entering group would have to represent a minimum of 10,000 tonnes of CO2e. A contract of that size would require a cropland farmer to have around 25,000 acres, making that option somewhat impractical since not many farmers have that amount of acreage. A practical alternative for most producers involves the use of an aggregator, which is an entity that aggregates (pools) producers. An aggregator would act like the "county elevator" for the carbon credits marketplace. An aggregator combines carbon credits from agricultural offset projects initiated by farmers, ranchers and private forest owners. Aggregators charge between eight to ten percent of the value of a carbon credit sold at market price on a yearly basis through the CCX (Krog, 2008).

How does a CCX contract for crop production or rangeland work?

Contracts through the CCX encompass a five-year period for crop production and/or rangeland management projects. After the five years, project owners[4] are free to renew the contract for another five years or let the contract expire. There is no limit on the number of times the project owner can renew his/her contract. Once a contract expires, project owners have no more obligations to the CCX or aggregator. However, if a project owner discontinues the approved sequestration production practice such as conservation tillage or grass planting prior to the end of the contract, the CCX or aggregator will ask the project owner to return the amount of carbon that would have been sequestered up to that point or pay for the same amount of carbon at market price. Additionally, the project owner will not be allowed to further participate in the CCX (CCX, 2008).

There are four different fees that the project owner has to pay to sell his/her carbon offsets in the carbon market. Besides the aggregator fee, there is a registration fee and trading fees of $0.15 and $0.05 per credit, respectively. Moreover, a verification fee of $0.10 to $0.12 per credit is charged to all project owners to pay a third party to verify the projects (Krog, 2008).

Finally, the CCX or aggregator sets aside 20 percent of the annual carbon credits from every project as an insurance pool, to protect against any carbon storage reversal that might occur in the unfortunate events such as fires or hurricanes (Krog, 2008). The maximum amount of storage reversal that a project owner could face is the amount withheld at the retention pool. In addition, the total amount of carbon set aside on the retention pool is paid back to the project owner the last year of the contract.

The CCX specifies that all crop production contracts are for a minimum of five years of continuous conservation or no tillage practice regardless of previous practices. In this arrangement, at least two thirds of the soil surface must be left undisturbed and at least two thirds of the residue on the field surface must remain (CCX, 2008). For more detailed conservation tillage practices allowed by CCX, refer to the Natural Resources Conservation Service (NRCS) National Handbook of Conservation Practices (NRCS, 2008a). An additional requirement is that soybeans should not be planted for more that two years of the five-year contract.

The volume of carbon that can be sold via crop production related tillage changes, measured in tonnes of CO2e, has been determined by the CCX (Figure 1). Moreover, Figure 2 shows the volume of carbon that can be sold through grass planting on cropland. Some special contracts can be arranged if the farmer can guarantee a specific practice on the land. Otherwise, the range of carbon sequestration estimated by the CCX tables is between 0.2 to 1.0 tonnes per acre per year, depending on the state and county where the land is located (Krog, 2008). For example, in south Texas (Figure 1 - blue area), the rate of carbon sequestration is 0.2 tonnes per acre per year and remains the same for each year of the five-year contract, as long as the verifier certifies that the landowner is following the specified conservation tillage practices. This means that at current prices the annual gross income potential is on the order of $1.20 per acre and the farmer has to use continuous reduced or no-till practices for the length of the contract.

In the case of rangeland management, sequestration practices include the employment of lowered stocking rates, along with rotational grazing to allow forage re-growth and seasonal use as needed in eligible locations. Eligible projects must be on non-degraded rangeland or previously degraded but restored rangeland, as a result of changes in management practices undertaken on or after January 1, 1999. For a more detailed description of CCX approved practices, refer to the NRCS Field Office Technical Guides, where guidelines for managing the controlled harvest of vegetation with grazing animals are published (NRCS, 2008b). All projects must take place on rangeland in which long-term average precipitation is no less than 14 and no more than 40 inches. The range of carbon sequestration estimated by the CCX table for rangeland management projects is between 0.12 to 0.52 tonne per acre per year, depending on the state and county in which the land is located, and the type of rangeland project, i.e. previously degraded or improved management (Figure 3).

A matrix of average annual gross returns per acre given different carbon sequestration rates and carbon prices is presented in Table 1. The different rates of carbon sequestration cover all offset ranges for practices in either crop production or rangeland management projects across the U.S. Different prices for carbon across the table were selected to show the impact of the price on average gross returns. Although the prices listed across the top of Table 1 are alternative market prices of carbon, the prices used to calculate expected gross returns are the actual prices paid to the project owner. In other words, the price used to calculate each average gross return is the market price minus all four fees: aggregator, verification, registration and trading fees.

To find the expected return per acre for a specific project, find the rate of sequestration for a specific county (Figures 1, 2 or 3) and then locate the market price of carbon at the top of Table 2; then scale it up or down to find the expected return for a specific farm or ranch size. To illustrate for a farming operation located in Nacogdoches County, locate the sequestration rate for Nacogdoches County (red area), in this case a rate of 0.6 tonne/acre/year and at $6/tonne, the expected average return would be $3.05/year/acre or $3,048/year on 1,000 acres or $6,096 on 2,000 acres. Also, using the same sequestration rate, 0.6, at current U.S. carbon price of $6 per tonne, and current European price of $35 per tonne, the expected average gross returns per acre would be $3.05 and $18.71 per year, respectively.

Conclusion

Concerns about climate change caused by human activities have greatly increased in the past several years. Many scientists believe that atmospheric build up of GHG concentrations is causing the climate to change. International and domestic efforts to stabilize the atmospheric GHG concentration emissions are currently in place. In the international arena, this mainly involves the Kyoto Protocol, while in the U.S. both federal and state programs are in place.

The U.S. Chicago Climate Exchange provides some opportunities for buyers and sellers to trade carbon credits. The agricultural industry could play a role in the reduction of atmospheric GHGs by sequestering carbon through crop production, rangeland management and afforestation offsets. However, there is a limited economic opportunity for landowners to participate in the carbon market as carbon prices have ranged over the years between $2 to $5 per tonne and currently is around $6 leading to returns on the order of $1-5 per acre. In addition, the current volume traded is small compared to what would happen with a widespread program and a large influx of participants would likely drive prices lower. On the other hand, factors such as:

- the recent ruling of the Supreme Court that granted the EPA authority to regulate motor fuel emissions;
- Climate Change-related Presidential platforms of both 2008 major party candidates; and
- Emerging state programs (e.g., California and the Northeast)

all seem to move toward a mandatory program in the U.S. such as a cap-and-trade program. If society decides to regulate GHG emissions, prices of carbon would likely increase, giving a greater economic incentive to farmers to participate in the carbon market. Moreover, an increase in carbon prices would likely increase farm values as well.

Endnotes

[1] The term Greenhouse gas refers to a group of gasses that adds to the reflective and heat trapping characteristics of the atmosphere. The name Greenhouse Gases is given due to the similarity of effects that atmospheric GHG concentrations have relative to the effects of the glass ceiling of a horticultural Greenhouse. In particular, GHGs are largely transparent to the Sun's energy coming to the Earth, but allow less of the solar energy reflected off of the earth's surface to escape into space trapping additional heat. As a result, the Greenhouse theory argues that the Earth's overall temperature increases when the concentration of greenhouse gases increases (Butt and McCarl, 2005, IPCC 2007a).

[2] Carbon offset is a financial instrument representing a reduction in GHG emissions. Although there are six primary categories of GHGs, carbon offsets are measured in metric tons of carbon dioxide-equivalent. One carbon offset represents the reduction of one metric ton of carbon dioxide, or its equivalent in other greenhouse gases. Carbon offsets are also called carbon credits, offset credits or carbon sequestered/absorbed.

[3] A cap-and-trade program establishes a GHG emitter mandatory emission cap and a commercial trade option where emitters buy offset credits from sequesters such as agricultural producers.

[4] Project owners are landowners or producers that enter into a carbon offset project contract with the CCX or an aggregator. Moreover, the project owner must present land maps to document ownership or control of a given track of land.

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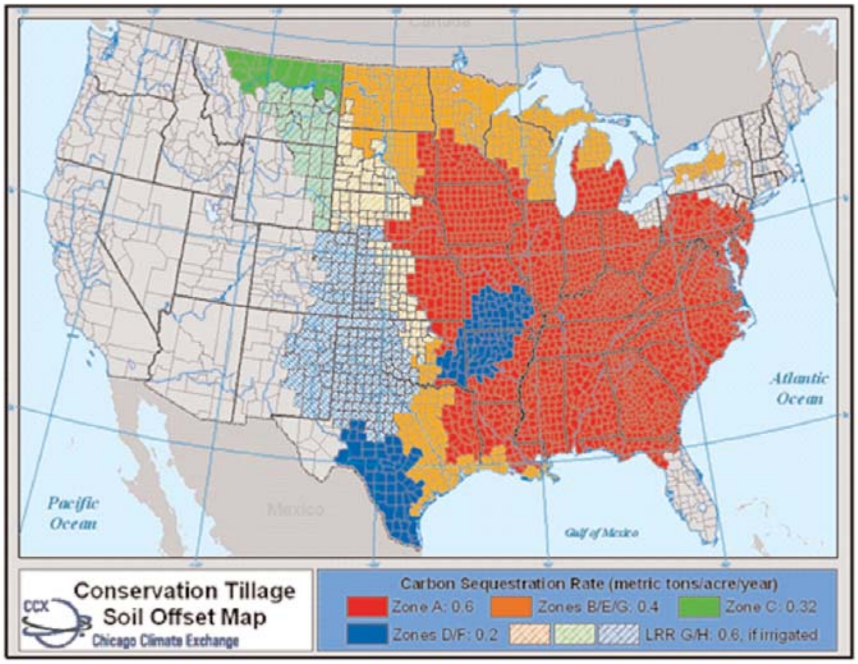
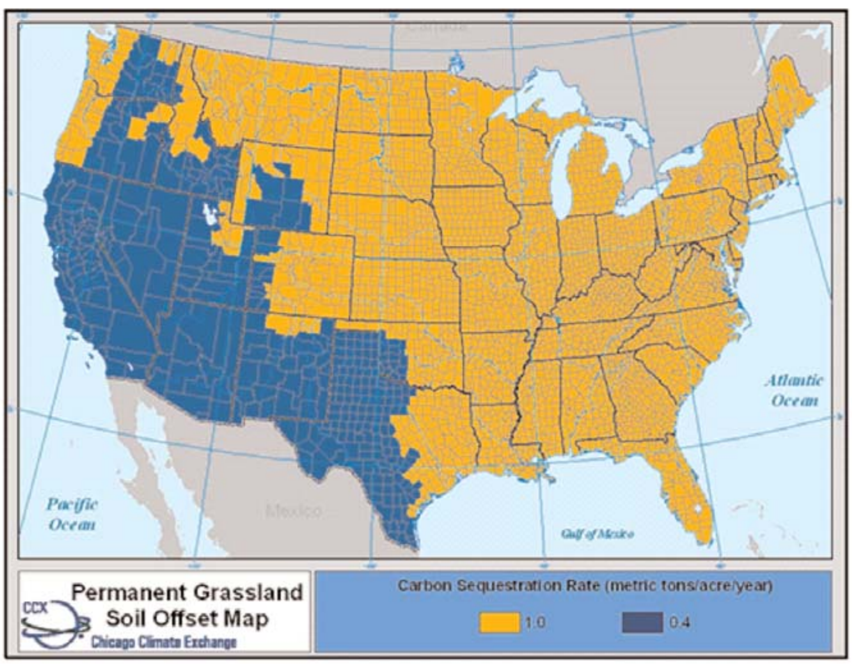
Figure 1. Conservation tillage soil offset map



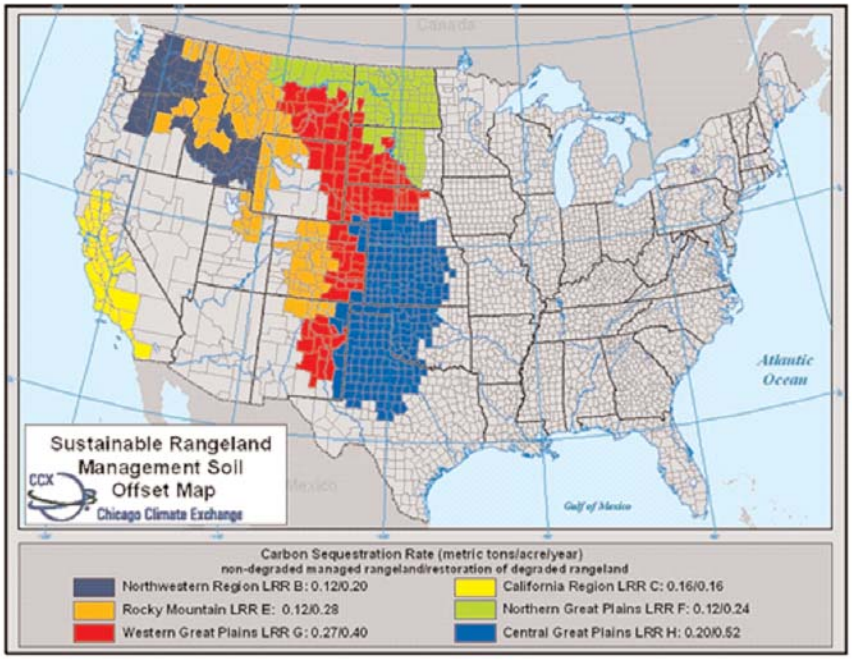
Source: Chicago Climate Exchange

Figure 2. Permanent grassland soil offset map



Source: Chicago Climate Exchange

Figure 3. Sustainable rangeland management soil offset map



Source: Chicago Climate Exchange

Table 1. Expected gross returns per acre of farm or ranch land with different carbon sequestration rates at selected carbon prices

Sequestration Rate (tonnes/ac)	Carbon Price ($/tonne) $2.00	$4.00	$6.00	$10.00	$15.00	$25.00	$35.00	$45.00
0.12	$0.18	$0.39	$0.61	$1.04	$1.58	$2.66	$3.74	$4.82
0.16	$0.24	$0.52	$0.81	$1.39	$2.11	$3.55	$4.99	$6.43
0.20	$0.30	$0.66	$1.02	$1.74	$2.64	$4.44	$6.24	$8.04
0.24	$0.36	$0.79	$1.22	$2.08	$3.16	$5.32	$7.48	$9.64
0.27	$0.40	$0.89	$1.37	$2.34	$3.56	$5.99	$8.42	$10.85
0.28	$0.41	$0.92	$1.42	$2.43	$3.69	$6.21	$8.73	$11.25
0.32	$0.47	$1.05	$1.63	$2.78	$4.22	$7.10	$9.98	$12.86
0.40	$0.59	$1.31	$2.03	$3.47	$5.27	$8.87	$12.47	$16.07
0.52	$0.77	$1.71	$2.64	$4.51	$6.85	$11.53	$16.21	$20.89
0.60	$0.89	$1.97	$3.05	$5.21	$7.91	$13.31	$18.71	$24.11
1.00	$1.48	$3.28	$5.08	$8.68	$13.18	$22.18	$31.18	$40.18

Note these do not account for alterations in the net income from crop production after alterations in yields and inputs like fertilizer, diesel, gasoline, water pumping, pesticides and labor.