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Reducing Greenhouse Gas Buildup: Potential Impacts On Farm-Sector Returns

International concern that human activities have enhanced the natural greenhouse effect of the earth's atmosphere by substantially increasing concentrations of greenhouse gases, and that additional warming of the Earth's surface and atmosphere may adversely affect natural ecosystems and humankind prompted negotiation of the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC was ratified by the U.S. on October 15, 1992 and put in force on March 21, 1994. The U.S. and other developed countries that were parties to the treaty were committed to "...adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic [manmade] emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs" (Article 4, paragraph 2a).

Concern that the voluntary approach under the UNFCCC has not resulted in sufficient greenhouse gas (GHG) emissions reduction or development of adequate emissions-absorbing terrestrial sinks could lead to further clarification in subsequent international agreements or national-level programs to control emissions without any additional treaty.

Several key features that national-level programs or international agreements would likely include are:

- national GHG emission reduction targets, particularly for carbon dioxide (CO_2), the most prominent GHG;
- programs to encourage development of emissions-absorbing land "sinks" to sequester carbon; and
- an emissions permit trading system for meeting emissions reduction targets.

How to Reduce U.S. GHG's at Lowest Cost

Two strategies to lower atmospheric concentrations of GHG's are abatement (reducing GHG emissions into the air) and sequestration (taking GHG's out of the air and retaining carbon in the soil or in above-ground biomass). Because carbon dioxide accounts for over 80 percent of U.S. GHG's, carbon compounds are a logical policy target. National policies to reduce carbon emissions could include regulation of fuel and other fossil energy use, or a system of tradable carbon emissions permits that would be issued by the government to manufacturers of energy and energy-intensive products—such as fuel, electricity, and selected chemicals. National policies to mitigate GHG's could include a program to establish GHG sinks, whereby carbon would be accumulated in agricultural soils through land use changes and forestry practices. A system of tradable carbon permits would increase agricultural input prices and decrease farm income, while carbon sequestration could provide a valuable role for agriculture to play in an overall national GHG reduction policy.

Any GHG reduction strategy would come at a cost to all sectors of the economy, but a system of tradable carbon emissions permits would be a relatively flexible approach, still meeting the goal of lower GHG emissions, but at less cost. Key to determining the magnitude of carbon permit prices in the U.S. would be the initial allocation of carbon permits consistent with desired GHG emission reduction, and the extent of allowable carbon permit trading. Prices of carbon permits (1 permit = 1 allowable ton of carbon emissions) would be higher with fewer permits issued, reflecting greater reductions in acceptable GHG emissions.

If a permit system is implemented within the U.S., an initial emissions permit allocation that reflects the national reduction target could be made to manufacturers of energy and energy-intensive products. Then, a mechanism could be created for firms to trade CO_2 emissions permits in order to lower the costs of reducing net GHG emissions. With permit trading allowed, companies with the ability to reduce emissions at relatively lower cost could sell their excess emissions rights to those whose costs of reducing emissions exceed the permit purchase price. Permit trading would help achieve emissions reduction at the least cost per ton of carbon and at least cost to the overall economy. But permit prices would be lower if international permit trading were allowed and if opportunities to manage resources for carbon sequestration were broadened.

Studies suggest that agricultural sinks could sequester about 60-64 mmt of

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A System of Carbon Permits Would Cut Net Returns for Crop and Livestock Producers

	2010 base	Carbon permit price $14/mt	$100/mt	$200/mt
	$ billion	*Percent change*		
Crops:				
Total value of production	100.5	0.1	0.6	1.1
Total variable costs	55.0	0.5	3.5	6.8
Net cash returns	50.4	-0.4	-2.7	-5.2
Livestock:				
Total value of production	117.3	0.2	1.1	2.2
Total variable costs	93.6	0.2	1.7	3.2
Net cash returns	23.8	-0.1	-0.9	-1.6
Crops and Livestock:				
Total value of production	217.9	0.1	0.9	1.7
Total variable costs	148.6	0.3	2.3	4.5
Net cash returns	74.2	-0.3	-2.1	-4.1

The carbon permit price would be determined, in part, by the level of emissions permit trading. The $14/mt carbon permit price assumes full international emissions permit trading; the $100/mt carbon permit price assumes limited international emissions permit trading; and the $200/mt carbon permit price assumes no international emissions permit trading.

Based on estimates from the ERS U.S. regional agricultural sector model for 2010.

Economic Research Service, USDA

carbon at an annual cost of about $1.5 billion. Private industry could arrange to pay farmers to sequester carbon, allowing a firm to stay within its emissions limit or meet a portion of its emissions reduction by purchasing a certifiable ton of sequestered carbon to offset a ton of emitted carbon. Credits for carbon sequestration in agricultural land sinks could also be established as a marketable commodity to be traded along with carbon emissions permits.

Farm policy could also be key to providing incentives to develop carbon sinks. The government could provide financial and technical assistance to farmers who wish to establish carbon sinks. In addition, a government carbon sequestration program could be devised to contract with landowners to engage in specific cultural practices that would remove GHG's from the air, thus reducing the need for more costly cuts in GHG emissions.

Agriculture Would Share GHG Reduction Costs

The net economic impact of a GHG reduction strategy on U.S. farmers would depend on the mix of policies and programs chosen to achieve GHG reduction goals. For example, implementation of a carbon permit system would raise fuel prices and add to farm production costs, although payments to manage farmland as carbon sinks would add to farm revenue. In 1996, farmers spent $28.7 billion (about 18 percent of total cash expenses) for carbon-intensive manufactured inputs—fuels, oils, electricity, fertilizer, and pesticides–for which prices would likely increase with carbon permit prices. In addition, U.S. farmers spent $11.5 billion (7 percent of cash expenses) on machine hire and custom work and on marketing, storage, and transportation—all services with significant energy requirements.

USDA's Economic Research Service (ERS) used a regional agricultural sector model to analyze the economic impact of an illustrative set of carbon emissions permit prices on U.S. agriculture. A carbon emissions permit program is assumed to raise input prices according to carbon embodied in the inputs and the carbon permit prices. Effects of energy cost increases on agriculture—livestock and 10 selected major crops—are estimated for three scenarios of carbon permit prices that would be determined, in part, by three levels of emissions permit trading: 1) a carbon permit price of $14 per metric ton of carbon, assuming full international emissions permit trading; 2) a carbon permit price of $100 per metric ton, assuming limited international emissions permit trading; and 3) a carbon permit price of $200 per metric ton, assuming no international emissions permit trading. With increased possibilities for permit trading and with increased incentives to reduce GHG emissions and sequester carbon, the carbon permit price would be expected to be on the low side.

A system of carbon permits would increase agricultural production costs, reduce commodity supplies, and increase prices and value of production. The negative effects of cost increases on income are partially offset by commodity price and revenue increases. The estimated impact on agricultural income is minimal under the lowest carbon permit price of $14 per metric ton. At this level, net cash returns are estimated to decline less than a half percent, and commodity prices increase by a half percent or less.

A System of Carbon Permits Would Reduce Soybean Acreage by Less Than 1 Million Acres

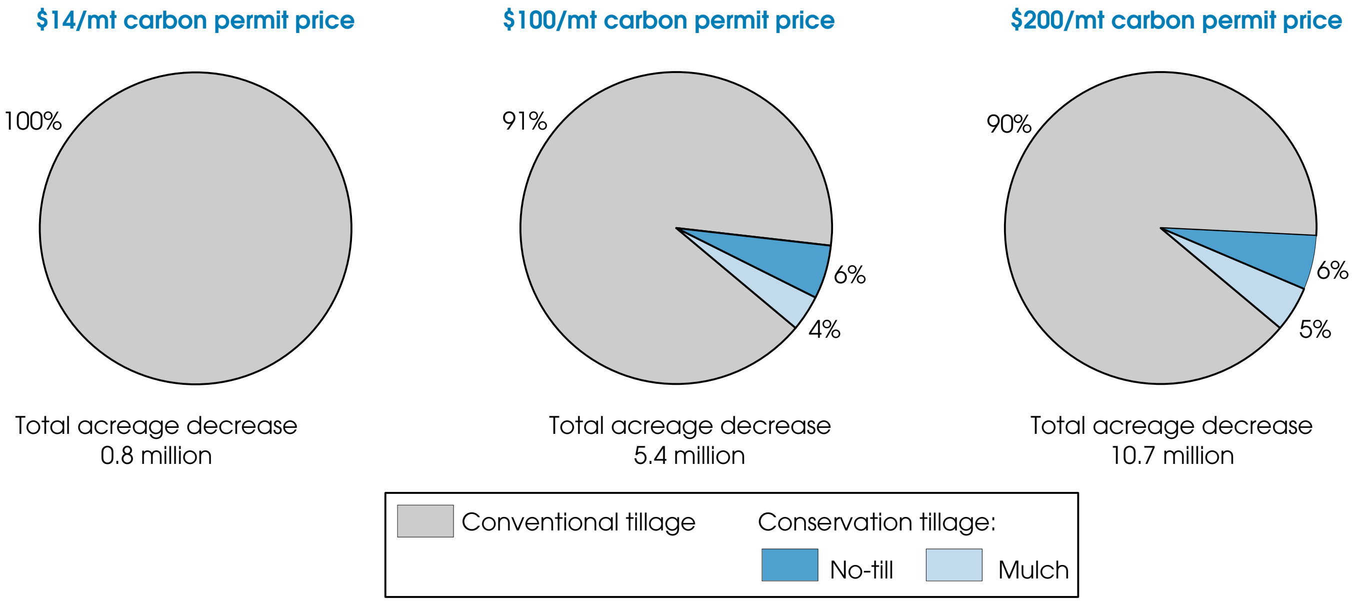
	2010 base	Carbon permit price $14/mt	$100/mt	$200/mt
	Million acres			
10 major field crops	342.1	-0.8	-5.4	-10.7
Feedgrains	107.7	-0.2	-1.8	-3.6
Wheat	77.5	-0.2	-1.4	-2.9
Soybeans	70.3	-0.1	-0.4	-0.8
Hay	62.5	-0.2	-0.8	-1.3
Cotton, rice, and silage	24.1	-0.1	-1.0	-2.1

Feed grains include corn, sorghum, barley, and oats. The carbon permit price would be determined, in part, by the level of emissions permit trading. The $14/mt carbon permit price assumes full international emissions permit trading; the $100/mt carbon permit price assumes limited international emissions permit trading; and the $200/mt carbon permit price assumes no international emissions permit trading.

Based on estimates from the ERS U.S. regional agricultural sector model for 2010.

Economic Research Service, USDA

Conventionally Tilled Land Would Account for Most of the Acreage Removed from Production In a System of Carbon Permits



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Acreage projections for 2010 for 10 major field crops from the ERS U.S. regional agricultural sector model.

Economic Research Service, USDA

As the carbon permit price increases, the impact on income is more pronounced, particularly for irrigated and chemical-intensive cropping systems. With a $100 carbon permit price, net cash returns decline about 2 percent. Price increases range from less than a half percent for soybeans, to 1 percent for wheat, about 3 percent for feed grains, and 3.5 percent for rice. Prices for milk, hogs, and broilers increase by about 1 percent, and beef prices increase by about 2.5 percent. With a $200 carbon permit price, net income and price effects are about double the effects of the $100 price.

With a carbon permit price of $14, land planted to the 10 selected crops declines by about 800,000 acres, about 0.2 percent. Plantings of three commodities—feed grains, wheat, and hay—fall by about 200,000 acres each; about 100,000 acres of soybeans are taken out of production; and land planted to rice, cotton, and silage drops a total of 100,000 acres. As the carbon permit price increases, soybean and hay acreage reductions decrease in relative importance because other crops higher in energy content (requiring more fuel and fertilizer inputs) incur greater cost increases. With carbon permit prices of $100 and $200, total planted acreage is reduced by 5.4 million and 10.7 million acres. Almost all land taken out of production is land that has been tilled conventionally (with or without moldboard plows); the costs of conventional tillage are more affected by a carbon permit system than are the generally less energy-intensive conservation tillage systems.

In the long term, economic adjustment would dampen the effect of production cost increases arising from a system of carbon permits. Results of the analysis indicate that the sector would respond to increases in energy costs by reducing input use, by altering management practices to include less energy-intensive practices, by changing crop mix, and by taking marginal (less profitable) land out of production.

Farmland Management: A Tool for GHG Reduction

Most U.S. agricultural soils have the potential to accumulate or sequester carbon through changes in land use and management. During the first 20-40 years under conventional tillage, the original carbon level of soil declines by 30-60 percent and then stabilizes at a new lower equilibrium. Because a great majority of U.S. cropland has been in production for many decades, large initial releases of carbon from that land have already occurred, and current releases are very low—estimates range between 2.7 and 15 million metric tons (mmt) annually. On land with carbon-depleted soil, shifting from conventional tillage to permanent grasses or no-till systems can result in soil carbon accumulation of up to 2,000 lbs. per acre per year. To return soils to their maximum carbon-carrying capacity takes about 50 years.

Conversion of marginal cropland and pasture to forest offers potential for agricul-

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How ERS Estimates Ag-Sector Costs From a Carbon Permit System

To estimate cost increases from a system of carbon permits, ERS uses a U.S. regional agricultural sector model designed for general-purpose economic, environmental, and policy analysis of the U.S. agricultural sector. The model represents agricultural markets and production enterprises in considerable detail and all elements of the model are calibrated to the latest available baseline, geographic, and cost of production data. The model is linked with regularly updated USDA production practice surveys, and geographic information system (GIS) databases, such as the National Resources Inventory.

The model predicts how changes in farm resources, environmental or trade policy, commodity demand, or technology will affect supply and demand of crops and livestock, farm prices and income, use of production inputs, participation rates and government expenditures for farm programs, and environmental indicators (such as erosion, nutrient and pesticide loadings, greenhouse gases, and others).

To calculate the increase in input prices caused by a carbon permit system, ERS multiplies the carbon embodied in each input by the carbon permit price, and then applies the increased input prices to each of the nearly 1,000 production systems contained in the model. The model determines how supply and use adjust to return commodity and input markets to equilibrium. The resulting changes in supply, use, acreage, price and other market indicators form the basis for determining the impacts of a carbon permit system on the agriculture sector.

tural carbon sinks. One study estimates that establishing a forest incentive program for reducing GHG's, patterned after the Conservation Reserve Program (CRP), could sequester about 44 mmt of carbon on some 22 million acres at a cost of $456 million annually at about $10/mt of carbon. More land could be converted and carbon sequestered, but at increasing cost per metric ton. Pastureland would be the source of most of the land converted to forest.

Although forests generally sequester more carbon and above-ground biomass than grassland, grassland soils are often higher in carbon content than forest soils. Grassland soil carbon is primarily a function of root mortality. Grass roots are thin, compact, and can extend to a depth of a meter or more. Forest soil carbon, on the other hand, is primarily a function of tree litter and fine root turnover near the surface. On land that was once prairie or is otherwise ill-suited to forestation, converting cropland to grasses sequesters carbon more economically and efficiently than forestation.

Studies of cropland conversion suggest that a 25-million-acre CRP-like program to plant marginal cropland to grasses could sequester about 8.6 mmt of carbon per year in the Great Plains. In the 18th CRP sign-up period (October-December 1998), mean land rental payments for states in the Great Plains ranged from about $32 to $40 per acre. With a similar payment rate for creating carbon sinks, a rough cost estimate of government outlays to shift 25 million acres from cropland to grasslands would be $800 million-$1 billion per year.

Use of conservation tillage, particularly no-till, can increase carbon levels in cultivated soil. Shifting 20 million acres from conventional tillage into no-till would annually sequester between 6.9 mmt and 11.3 mmt of carbon, according to soil scientists Kern and Johnson. ERS estimates that, between 1989 and 1996, planted cropland using conservation tillage increased from 71.7 million acres (26 percent of planted acres) to 103.8 million acres (35 percent of planted acres), with no-till accounting for nearly all the increase. In 1996, acreage under no-till alone accounted for 15 percent of total planted acreage.

The cost of providing farmers with incentives to shift an additional 20 million acres into no-till is speculative, because sorting out the relative importance of multiple factors contributing to use of no-till is difficult. An incentive provided in the Food Security Act of 1985 (and continuing through the 1996 Farm Act) links agricultural program payment eligibility to adoption of conservation systems on highly erodible land (HEL). "Conservation compliance" requires farmers with HEL to implement conservation plans—such as the adoption of conservation tillage—if they wish to receive USDA program benefits.

Conservation tillage can be more profitable than conventional tillage under some conditions. But factors such as the higher level of management skills needed, capital outlays for new machinery, and the long-term nature of the decision appear to be hindering further adoption. So it is likely that the mitigation of GHG emissions via expanded use of conservation tillage would require additional economic incentives.

Farmers Could Bank On Carbon Sinks

Agriculture could benefit from a national greenhouse gas emissions reduction strategy that includes a significant role for terrestrial (land) carbon sinks. Carbon sinks require land, and farms account for almost half of all U.S. land in the 48 contiguous states. Given appropriate economic inducements, significant areas could be managed to increase carbon stored in soils and in above-ground biomass.

The role of terrestrial carbon sinks in mitigating GHG emissions is in the early stages of development. If carbon sinks are to be established by planting cropland to forest or grass or by expanding adoption of conservation tillage, then policies to promote agricultural carbon sinks must provide producers with incentives to enter into longrun land management commitments. Studies by both ERS and other observers conclude that the changes would have to remain in effect for extended periods of time (perhaps a minimum of 20 years) to prevent re-release of carbon sequestered in soils or biomass.

To assess how government policies might address carbon sequestration through agriculture, it is helpful to view land ownership as a bundle of separate interests (claims), each conveying the right to use a parcel of land in a particular way (e.g., a utility easement or mineral rights). The set of interests associated with any given parcel may be held by one agent (e.g., the farm operator or landowner) or may be distributed among multiple agents (public and private). The market value of any interest reflects expectations about the present value of all current and future uses the interest allows.

Establishing agricultural GHG sinks within a market framework for carbon emissions permits would create a new economic interest in farmland—the right to manage it for increased carbon content. Landowners and farmers could then choose to sequester carbon if its net returns exceed those from other uses over some relevant time horizon. The general idea is that firms with high emissions reduction costs, such as electric power generators, would mitigate the environmental impacts of their emissions by contracting with other firms (such as farms) to engage in specific sequestration activities. If the price of carbon emissions permits were sufficiently high, it is conceivable that firms would find it economical to pay farmers to sequester enough carbon to significantly offset national GHG emissions. In the case of lower-than-desired levels of carbon sequestration, the government could assess whether or not the social benefits of sequestering carbon are sufficient to justify government expenditures to increase land in agricultural carbon sinks.

If government outlays are determined to be justified, carbon sequestration could become an explicit conservation objective of farm policy, implemented with new or existing programs. Conservation programs authorized in the 1996 Farm Act encourage farmers and ranchers to reduce soil erosion, protect wetlands, improve water quality, and enhance wildlife habitat. USDA conservation program incentives for farm owners and operators include annual rental payments to landowners for retiring environmentally sensitive lands, cost-share assistance to establish practices that reduce environmental damage, and opportunities for education and technical assistance.

If promoting carbon sequestration were to become an explicit goal of USDA conservation policy, these tools could be modified or expanded to encourage the adoption of agricultural practices that increase the quantity of carbon stored in soils and biomass, and to help satisfy possible emissions reduction requirements. Unlike other conservation programs, all of which are either short-term or contain release clauses, any policies promoting the exit of agricultural land from production for as long as 25 years would need to be further evaluated under different future global food security and price scenarios. AO

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