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The Role of Agriculture in Reducing Greenhouse Gas Emissions

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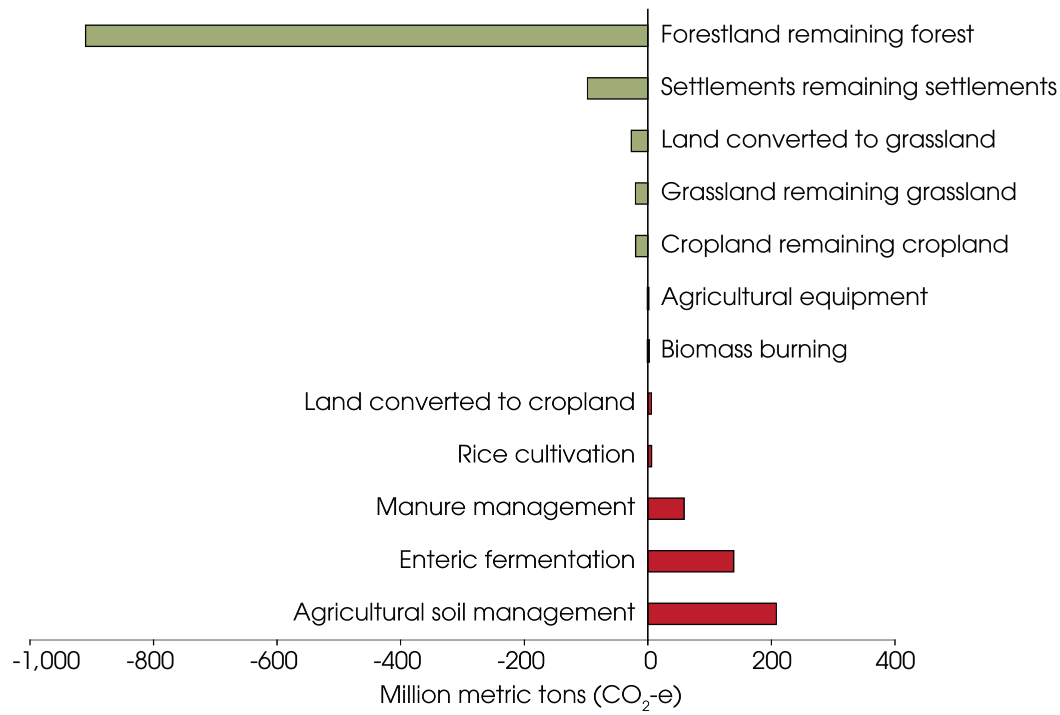
Agriculture could play a prominent role in U.S. efforts to address climate change if farms and ranches undertake activities that reduce greenhouse gas (GHG) emissions or take greenhouse gases out of the atmosphere. These activities may include shifting to conservation tillage, reducing the amount of nitrogen fertilizer applied to crops, changing livestock and manure management practices, and planting trees or grass. The Federal Government is considering offering carbon offsets and incentive payments to encourage rural landowners to pursue these climate-friendly activities as part of a broader effort to combat climate change. The extent to which farmers adopt such activities would depend on their costs, potential revenues, and other economic incentives created by climate policy. Existing Federal conservation programs provide preliminary estimates of the costs of agricultural carbon sequestration.

Figure 1 shows the contributions of broad categories of agricultural and forestry practices and land uses to GHG emissions for the United States in 2007, with red bars representing emissions and green bars representing sequestration, which takes carbon dioxide out of the atmosphere. Changes in these practices and rural land uses can shift both the red and green bars to the left, thereby helping to address climate change. These farming practice and land use changes also potentially affect farm profits, meaning that if climate policies aim to involve farmers voluntarily, they would likely need to include payment mechanisms to induce farmers to adopt relevant practices.

Figure 1

Agricultural sector GHG emissions and sinks, 2007



CO_2-e= Equivalent carbon dioxide. CO_2-e is a measure of the global warming caused by all types of greenhouse gases, using the equivalent amount of carbon dioxide (CO_2) as the reference.

Note: A settlement, for our purposes, includes all developed land, including transportation infrastructure and human settlements of any size. Enteric fermentation refers to the microbial fermentation process that occurs in an animal's digestive system and produces methane (CH_4) as a byproduct.

Source: Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007 (April 2009), tables 6-1 and 7-1; agricultural equipment emission source is from tables 3-13 and 3-14.

Climate Change Policies Can Provide Roles for Agriculture

The Federal Government is considering a range of actions to reduce GHG emissions. In addition to possible Federal action, State governments and private organizations may also include agriculture as part of their efforts to reduce GHG emissions. The costs, benefits, and overall emission reductions of agricultural mitigation efforts depend on how climate change policy is structured and its stringency.

Carbon Offsets in a Cap-and-Trade System

U.S. efforts to reduce GHG emissions could take the form of a nationwide cap-and-trade system on GHG emissions from the burning of fossil fuels, which account for 80 percent of U.S. emissions. Under this system, fossil fuel sources, such as oil refiners and electricity generators, must have a permit for every ton of emissions. The number of permits that the Government makes available would be the "cap." Under proposed cap-and-trade systems, GHG permits would not be required for emissions arising from agricultural management practices or land use change.

A cap-and-trade system could encourage agricultural mitigation by making agricultural activities eligible for offset credits. Depending on the eligibility rules for offset credits, farmers who increase their use of no-till practices or use nitrogen fertilizer inhibitors, for example, could receive credits for their reduced emissions. They could then sell these credits directly to the industrial sources covered by the cap-and-trade permit requirement or to brokers. Offset credits could be submitted by industrial sources in place of their required emission permits.

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Options for Reducing GHG Emissions from Agricultural Enterprises and Increasing Carbon Sequestration on Agricultural Land

Reducing Greenhouse Gas Emissions From Crop and Livestock Production

Livestock and dairy operations emit greenhouse gases through the digestive processes of ruminants (primarily cattle and sheep) and through the decomposition of manure. Livestock managers can reduce methane emissions by changing livestock feeds. Dairy and hog producers can install digesters to capture methane produced during manure storage; the captured methane can then be used to generate electricity. Digesters reduce emissions by converting methane emissions that would have arisen under other methods of manure disposal into less-powerful CO_2 and by generating energy that replaces CO_2 emissions that would have come from fossil fuel based electricity.

Crop producers can change nutrient management practices to reduce emissions from nitrogen fertilizers and manure applied to farmers' fields. Practices that help farmers reduce nitrogen applications without reducing yields include plant tissue testing, soil testing, precision application, use of slow-release fertilizers or nitrification inhibitors, and changes in application timing to better match plant uptake of nutrients (Smith et al., 2008).

Farms and other agricultural enterprises emit CO_2 when they burn gasoline or diesel in vehicles and machinery. If farmers improve operating efficiency or adopt farming techniques that use less fuel, such as no-till, they will reduce their fossil fuel-based GHG emissions. While reducing on-farm fuel use can improve farm profitability and reduce carbon emissions, the potential impact on overall GHG emissions is relatively low because fossil fuel use by agriculture is a small portion of total U.S. fuel consumption.

Producing Renewable Energy on Agricultural Land

Farmers can also contribute to reducing GHG emissions by growing the feedstocks used for biofuels or by installing wind turbines or solar panels on their land. However, indirect land use effects arising from increased demand (in the case of biofuel feedstocks) or reduced supply (in the case of wind or solar power) of crops may lessen or even eliminate the emissions reduction (Fargione et al., 2008).

Increasing Carbon Sequestration on Agricultural Land

To increase carbon sequestration, farmers can adopt practices that increase crop residues left on the field and the volume of organic matter stored in the soil. These practices include switching from conventional tillage to conservation tillage or no-till, reducing or eliminating fallow as part of planned crop rotations, switching from annual to perennial crops, increasing field residues through irrigation, fertilization, planting hay or cover crops, or using additional organic material, such as manure. In some circumstances, these activities present a tradeoff between two greenhouse gases—conservation tillage may increase both carbon sequestration, which mitigates climate change, and nitrous oxide emissions, which contributes to it (Johnson et al., 2007). If these practices reduce yields, then indirect land use changes may also occur.

The box "Options for Reducing GHG Emissions From Agricultural Enterprises and Increasing Carbon Sequestration on Agricultural Land" provides descriptions of agricultural activities that reduce atmospheric concentrations of GHG and could possibly be eligible for offsets. Reductions in fossil fuel use and the production of biofuel feedstocks or other renewable energy would likely not be eligible for offset credits.

Agricultural participation in proposed cap-and-trade markets would be voluntary and, therefore, a potential source of income for farmers. Farmers would be able to decide whether they wanted to undertake activities eligible for offset credits based on the costs of the offset activity and the prices of the offset credits they would earn.

Incentive Payments for Reducing GHG Emissions

Another policy option is to offer direct incentives for agriculture's mitigation activities, an approach similar to current Federal conservation programs, such as the Conservation Reserve Program (CRP). The Government would set rules for eligible practices and payment amounts, just as it does for other conservation programs. To offer incentive payments, the Government would set aside a pool of money or reserve permits to pay farmers for mitigation activities.

Policies to Encourage Renewable Energy Production from Agricultural Sources

A variety of policies, such as the Renewable Fuel Standard, which ensures that transportation fuel sold in the United States contains a minimum volume of renewable fuel, or proposed Renewable Portfolio Standards, which would apply similarly to electricity production, encourage agricultural producers to grow the feedstocks used for biofuels or to provide land for wind or solar power generation.[1]

[1]See http://www.ers.usda.gov/Briefing/Bioenergy for a discussion of the economic and environmental impacts of biofuel policies.

Existing Agricultural Programs Provide Insights into Possible GHG Mitigation Policies and Costs

Existing Federal conservation programs provide insights into the costs of agricultural mitigation and yield lessons for the design of greenhouse offset contracts or incentive payments. The CRP and other programs, such as the Environmental Quality Incentives Program (EQIP) and the Wetlands Reserve Program, offer payments for activities similar or identical to the activities that would likely be eligible for GHG offsets.

The Conservation Reserve Program (CRP)

CRP offers payments to farmers to voluntarily retire highly erodible or environmentally sensitive cropland from production for 10-15 years. Enrolled land is then planted to grass or trees, thereby reducing water pollution, improving wildlife habitat, sequestering carbon, and providing other environmental benefits. More than 34 million acres were enrolled in the CRP as of March 2008, either through general or continuous sign-up, making it the largest environmental program on private lands in the United States.[2] The USDA Farm Service Agency (FSA) has estimated that those acres sequestered 48 million more metric tons of CO_2 than if the land had remained in previous uses (FSA, 2008).

[2]The Food, Conservation, and Energy Act of 2008 reduced CRP's enrollment cap to 32 million acres as of October 2009.

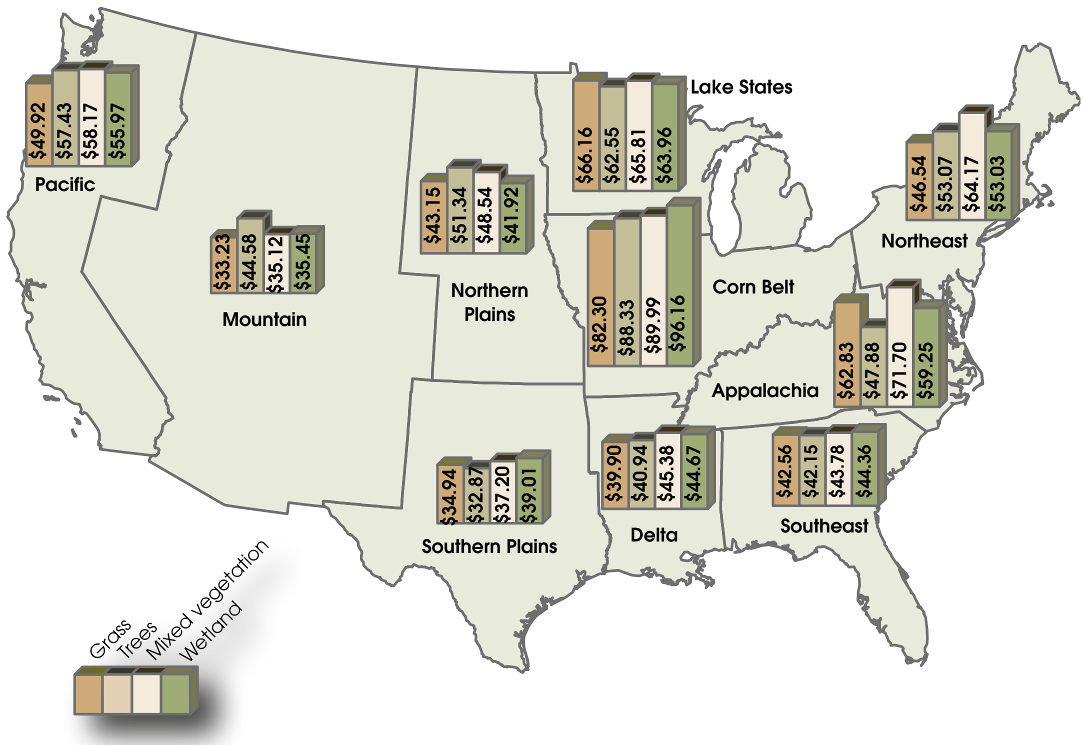
Figure 2 shows the average per-acre annual payments that landowners received for general sign-up contracts under the CRP in 2008. Payments are highest overall in the Corn Belt, reflecting the higher opportunity cost of taking land out of crop production there.

Total annualized CRP payments[3] can be combined with FSA estimates of sequestration rates (based in part on Eve et al., 2002) to provide preliminary evidence of the payments farmers would require to sequester carbon through land retirement. The total annual payments that CRP participants receive can also be considered a proxy for the costs they face for retiring cropland; presumably farmers would not participate in the CRP if their costs were substantially higher than the payments they receive. These cost estimates are shown in table 1. Estimated average sequestration costs through tree planting range from $7 to $32 per ton of CO_2 (all references are to metric tons). Average sequestration costs through grass planting are higher, ranging from $29 to $82 per CO_2 ton, since the forgone agricultural income is roughly the same regardless of vegetation planted (for land enrolled in the CRP) but the amount of CO_2 sequestered is lower.

[3]In addition to the annual rental payments FSA makes to farmers enrolled in the CRP, participants may also be reimbursed for a portion of the costs of establishing a cover crop (e.g., planting grasses or trees). Total average annualized CRP payments are calculated by amortizing the cost share payments over 20 years at 5 percent and adding them to the average annual payments shown in figure 2.

Figure 2

Mean annual payment per acre for CRP general sign-up contracts, by vegetation type, March 2008



Source: USDA, Economic Research Service calculations based on Conservation Reserve Program data.

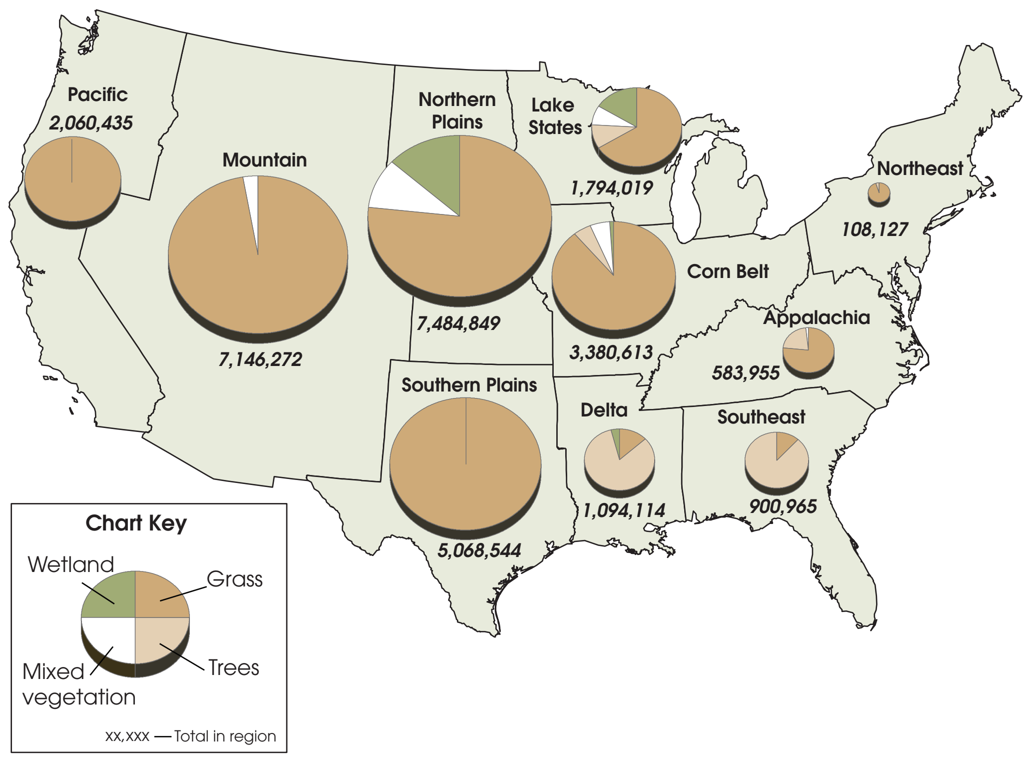
These costs indicate that if a carbon market were paying $13/ton of CO_2 then owners of the average tree-planted CRP acre in 5 of the 10 regions (Northeast, Appalachia, Southeast, Delta, and Southern Plains) would have found it profitable to enter a carbon market. These estimates are averages, so a range of costs would be exhibited in the individual regions and we would expect at least some tree-planted acres to enter at this price in all regions. By way of comparison, the U.S. Environmental Protection Agency estimates that allowance prices associated with congressional cap-and-trade proposals would range from $12 to $41 per ton CO_2 in 2013 and from $13 to $59 per ton of CO_2 in 2020.

Actual carbon sequestration levels and costs through land retirement may be lower or higher than these estimates. Only certain kinds of cropland are eligible for CRP payments, so some farms that could provide less costly sequestration may not have been eligible. Furthermore, eligible farms were selected for the program based on many criteria besides their carbon sequestration. These features would likely be changed under any new program that focused on climate benefits, thus providing less expensive carbon sequestration. On the other hand, for climate policies to effectively provide additional carbon sequestration through land retirement, farmers must enroll additional land beyond the current CRP. This effect could cause carbon sequestration costs to be higher than portrayed in table 1.

The Conservation Reserve Program also provides evidence of the acreage that landowners would be likely to offer in a carbon market through individual practices. Figure 3 shows the acres enrolled in general sign-up CRP contracts by vegetation type and region. Grass predominates in all regions except the Southeast and Delta. The small proportion of trees in most regions suggests that farmers were willing to plant trees on only a relatively small proportion of accepted acres at prevailing CRP payment rates. This result

Figure 3

Acres enrolled in general sign-up CRP contracts, by vegetation type and region, March 2008



Source: USDA, Economic Research Service calculations based on Conservation Reserve Program data.

Table 1

Estimated average costs of carbon sequestration through land retirement, based on CRP enrollment

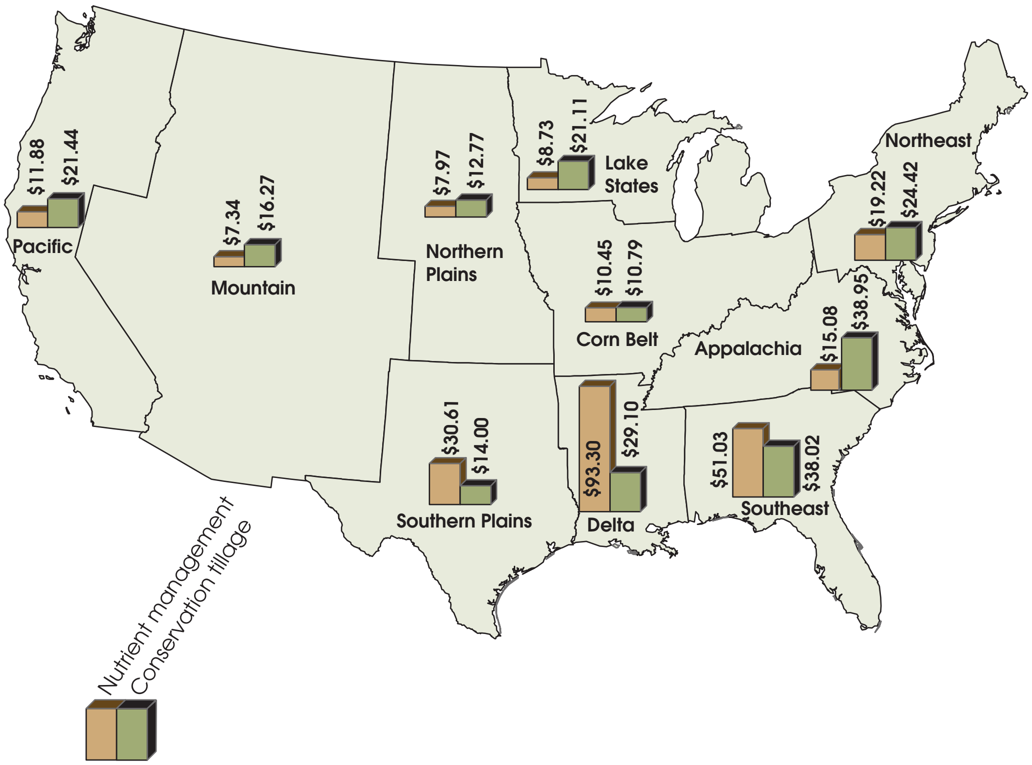
Region	*Average cost per metric ton of CO_2-e (grass)*	*Average cost per metric ton of CO_2-e (trees)*
Northeast	$57	$12
Appalachia	$73	$11
Southeast	$82	$8
Delta	$29	$8
Corn Belt	$68	$32
Lake States	$68	$24
Northern Plains	$43	$16
Southern Plains	$38	$7
Mountain	$55	$20
Pacific Coast	$69	$15

CO_2-e= Equivalent carbon dioxide. CO_2-e is a measure of the global warming caused by all types of greenhouse gases, using the equivalent amount of carbon dioxide (CO_2) as the reference.

Source: USDA, Economic Research Service calculations based on Conservation Reserve Program data.

Figure 4

Average payment per acre under EQIP contracts, by practice and region, 2008



Source: USDA, Economic Research Service calculations based on Conservation Reserve Program data.

suggests that substantial numbers of tree-planted acres are likely to be offered to an offset market only if landowners receive higher payments than shown in table 1.

Policy decisions about whether a particular acre would be eligible for CRP enrollment and receive GHG offset credits would affect the owner's willingness to participate in the offset market and/or the CRP, as well as the size of the payment required from each.

Environmental Quality Incentives Program (EQIP)

EQIP provides payments to farmers who adopt a wide range of conservation practices for crop and livestock production. To participate, a producer enters into a contract to implement a specific conservation practice for 1 to 10 years. Per-acre EQIP payments for two of the supported practices that have the potential to contribute to GHG reduction efforts—conservation tillage and nutrient management—are shown in figure 4.

EQIP paid out $42.5 million in 2008 for conservation tillage contracts on 2.7 million acres. If those farms sequestered 0.59 tons of CO_2 per acre, an average estimate, then 1.6 million tons of CO_2 would have been sequestered through conservation tillage, translating to an equivalent outlay of $27 per ton of CO_2. As with the CRP calculations, actual costs of adopting no-till practices under a climate policy may be lower or higher, depending on the success of new policies in bringing in farms that have the lowest carbon sequestration costs but have not yet adopted no-till.

EQIP paid out $35.7 million in 2008 for nutrient management contracts on 4.0 million acres. Many different nutrient management practices are supported by EQIP, so it is not possible to provide a simple estimate of the GHG mitigation resulting from these contracts.

Conclusion

U.S. agriculture can contribute to efforts to reduce GHG emissions through increased carbon sequestration, reduced methane and nitrous oxide emissions, and increased renewable energy production. Although conservation programs have been developed and implemented to achieve a host of objectives beyond carbon sequestration, they share several key characteristics of proposed offset markets or other incentives for reducing agricultural GHG emissions, providing a glimpse of the potential farm response to policy incentives for reducing GHG emissions. Further research will develop more precise cost estimates from these programs and for a wider variety of mitigation activities. Forthcoming research will also help identify policy provisions that can encourage cost-effective agricultural efforts and will consider the economic implications of the simultaneous offering of both conservation programs and GHG offsets.

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This is the second in a continuing series of economic briefs on climate change and U.S. agriculture. You may also be interested in *Agricultural Land Tenure and Carbon Offsets*, EB-14, available at: www.ers.usda/Publications/eb14/. For additional information, see the ERS Global Climate Change briefing room, at: www.ers.usda.gov/Briefing/globalclimate/.

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