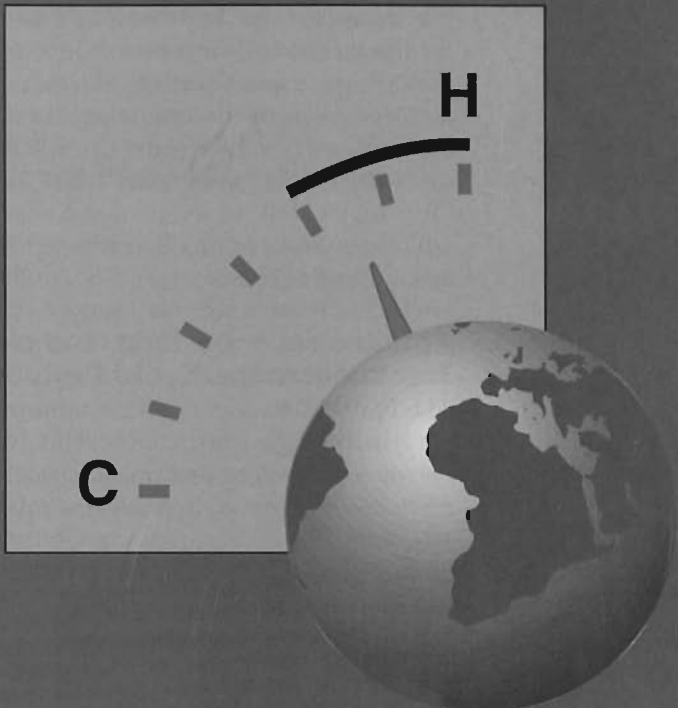


Curbing Greenhouse Gases

Agriculture's Role

by Bruce A. McCarl and Uwe Schneider

Even though the overall consequences of greenhouse gas emissions remain uncertain, many scientists believe the risks of negative impacts felt through global warming are substantial and suggest that society turn its attention to emission reduction. Emissions might, for example, be reduced through a new market mechanism to buy and sell emission permits, and by other means. Why might such a market arise? How might agriculture participate? How might such a market influence agricultural profitability? And how will agricultural operations be changed by the presence of a market or other means to mitigate greenhouse gas?

The Kyoto Protocol—An agreement to reduce greenhouse gas emissions

In December 1997 in Kyoto, the Intergovernmental Panel on Climate Change (IPCC) reached an agreement to reduce greenhouse gas emissions. The agreement is commonly called the Kyoto Protocol, after the Japanese conference place. Developed countries negotiated emission reduction targets for listed greenhouse gases. The Protocol requires each participating party to "have made demonstrable progress in its commitments" by 2005 and to achieve the agreed upon emission reduction within the period 2008 to 2012. The emission reductions may be achieved by "source" and "sink" improvements. Sources refer to gas-generating processes; sinks refer to processes which remove gases. Reilly discusses the Kyoto results in more detail elsewhere in this issue.

Emissions trading—Creating a market for emission rights

Importantly, the Protocol encourages emissions trading. Emissions are limited by country—not by individual emitting businesses. Most likely (though not yet decided), U.S. policy will include a domestic emissions trading system, much like the trading scheme used in the U.S. acid rain program. The total level of U.S. permitted emissions would be allocated as tradable permits among eligible parties. Emitters with high emission reduction costs could then buy emission permits from lower-cost sectors. It is this market mechanism, coupled with the perception that agriculture can provide lower-cost emission reductions, that interests agriculturists.

Trading is likely to be allowed across the spectrum of greenhouse gases. To place gases on an equal footing, the IPCC developed the concept of global warming potential (GWP). GWP compares the ability of different greenhouse gases to trap heat in the atmosphere. The IPCC uses carbon dioxide as a reference gas and calculates GWPs for three reference time horizons: twenty, one hundred, and five hundred years. For example, over a one-hundred-year time horizon, one metric ton of methane and 21 metric tons of carbon dioxide trap an equal amount of heat in the atmosphere, so the GWP of methane is 21. Equivalently, the GWP of nitrous oxide is 310. The other gases—HFCs, PFCs, and SFs—have GWPs of several thousand. Agriculture serves as a source or sink for carbon dioxide, methane, and nitrous oxide.

Agriculture, emissions, and sinks—Treatment in the Kyoto Protocol

The Protocol mentions agriculture (including forestry) as both an emitter and a sink. Greenhouse gas mitigation efforts and emission trading markets may affect agriculture in four principal ways. First, agriculture contributes to emissions by releasing substantial amounts of methane, nitrous oxide, and carbon dioxide. Consequently, agriculture may need to reduce emissions. Second, agriculture provides a potential means for emission mitigation by creating sinks. Third, agriculture may serve as an alternative source of fuel to replace fossil fuels which emit greenhouse gases during combustion. And fourth, agriculture may face higher or lower input and product prices because of policies designed to reduce greenhouse gases beyond the farmgate.

Agriculture—A source of greenhouse gases

Annex A of the Protocol lists emissions from enteric fermentation (methane emissions through microbial fermentation in digestive systems of animals), manure, rice cultivation, soil, and field burning. The IPCC estimates that on a global level agriculture's share of total anthropogenic emissions amounts to about 50 percent of methane, about 70 percent of nitrous oxide, and about 20 percent of carbon dioxide. Sources of methane emissions from U.S. agriculture include rice and cattle production. Nitrous oxide emissions depend on manure, tillage, and fertilizer practices. Carbon dioxide emissions stem from burning fossil fuels, tillage, deforestation, biomass burning, and land degradation. Contributions across countries vary substantially, with the greatest differences occuring between developing and developed countries. Current deforestation and land degradation mainly occurs in developing countries. Agriculture in developed countries uses more energy, more intensive tillage systems, and larger fertilizer applications, resulting in fossil-fuel-based emissions, reductions in soil carbon, and emissions of nitrous oxides. In addition, animal herds emit high methane levels.

Adams and co-authors (1992) have examined the costs of various methane and nitrous oxide reduction strategies. To reduce methane emissions by one million tons, costs ranged from about $600 per metric ton CH_4 for reduced rice fertilization to nearly $4,000 for the beef tax remedy. They estimated the marginal costs to reduce nitrous oxide emissions at about $4,700 per metric ton N_2O. These costs can be placed on a CO_2 basis by using the IPCC's global warming potential (GWP) for those gases. On a CO_2 basis, the marginal costs are equivalent to $28 (change in rice fertilization), $190 (beef tax), and $15 (nitrous oxide reduction) per ton CO_2.

Agriculture—A sink for greenhouse gases

The Kyoto Protocol allows credits for emission sinks through afforestation and reforestation. Provisions allow for consideration of additional sources and sinks. Agriculture can serve as an emission sink mainly offsetting CO_2 emissions. Management practices can increase soil carbon retention (commonly called carbon sequestration). Such practices include land retirement (conversion to native vegetation), residue management, less-disruptive tillage systems, land use conversion to pasture or forest, and restoration of degraded soils. While each of these can increase the carbon-holding potential of the soil, some issues are worth noting. First, soils can only increase carbon sequestration up to a point. Retained carbon increases until it reaches a new equilibrium state that reflects the new management environment. As the soil carbon level increases, soil absorption of carbon decreases and soil potential to become a future emission source increases. Second, subsequent alteration of the management regime can lead to carbon releases. For example, when farmers increase tillage intensity the soil releases carbon rapidly. Third, carbon management can reduce agricultural productivity. And fourth, the carbon-holding capacity of soils may diminish as the climate warms.

Soils also provide a sink for other gases, but much less is known about these processes or capacities. Estimates indicate that soils serve as a sink for methane, taking up 10–20 percent of current emissions. The soil-to-atmosphere exchange of nitrous oxide is not well understood at the present time. Studies on grasslands indicate that conversion of grasslands to croplands tends to increase emissions of nitrous oxide, but conversion also tends to increase the soil sink for methane.

Adams and co-authors (1999) recently estimated the marginal costs of sequestering carbon by tree plantations. They estimate that marginal costs increase from $4.50 to $17 per ton CO_2 depending on the amount of carbon sequestered. Their results agree with those of a number of previous studies. We did not find sectoral-level estimates of carbon sequestration costs through CRP expansion, tillage method changes, or forest harvest practice alterations.

Agriculture—A way of offsetting net greenhouse gas emissions

Agriculture may provide biomass for new or converted electrical power plants or liquid fuels for use in automobiles and other equipment. Switch grass or short-rotation woody crops could be produced for these new systems. Burning biomass would reduce net CO_2 concentration into the atmosphere because the photosynthetic process of biomass growth removes about 95 percent of CO_2 emitted when burning the biomass. Fossil fuel use, on the other hand, releases 100 percent of the contained CO_2. Similar arguments can be made for ethanol production for liquid fuels. Commodities such as corn and other cellulous-laden products can be converted into ethanol, a gasoline substitute. Again, the photosynthetic process of crop production substantially offsets emissions of CO_2.

A few studies have tried to assess the economic costs of these mitigation strategies. Recently, McCarl, Adams, and Alig estimated the costs of producing energy in biomass-fueled electrical power plants. Their estimates indicate that a million BTUs from biomass will cost $1.45 to $2.16, in contrast to a million BTUs from coal at a cost of $0.80. Thus, we can compute the cost of CO_2 emission reductions by dividing the cost difference by the amount of CO_2 saved from burning biomass instead of coal. These cost indicators are in the neighborhood of $10 to $20 per ton CO_2.

Economists have also investigated, over many years, the economics of ethanol. Recently Jerko showed that ethanol production costs between $1.20 and $1.35 per gallon. Production of fossil-fuel based gasoline costs only about $0.60 per gallon. Using the price difference and an average carbon content of 2.26 kg per gallon of gasoline, marginal abatement costs of switching from fossil fuel to ethanol range between $72 and $90 per ton CO_2.

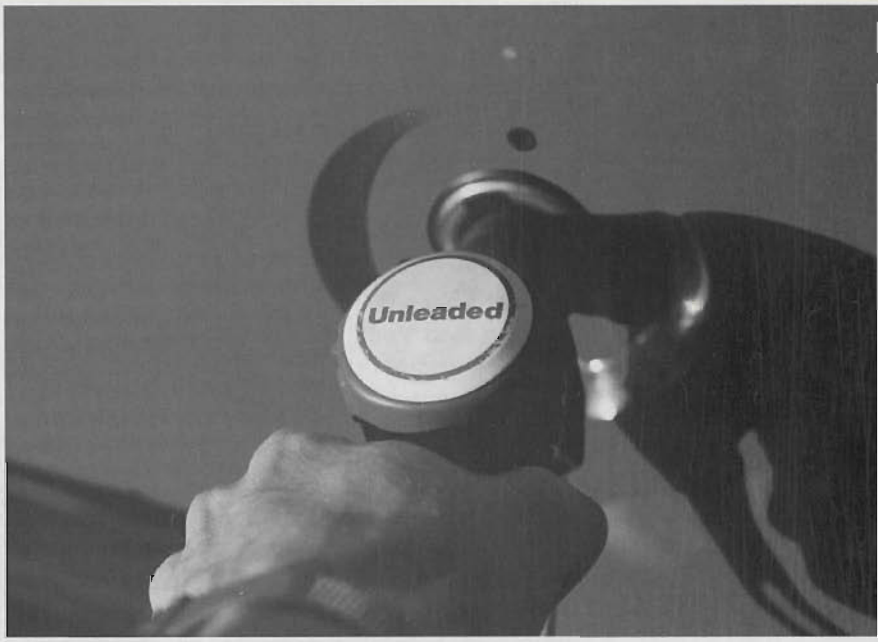
Agriculture—Operating under fuel taxes

The need to reduce emissions and the implementation of emissions trading will likely affect fossil fuel prices. For example, diesel fuel distributors might need to purchase an emissions permit, effectively raising fuel prices. Similarly, the United States might implement some sort of fuel tax. The tax and corresponding transportation cost increases might influence the cost of petrol-based agricultural chemicals and fertilizers as well as on-farm fuel prices and off-farm commodity prices.

McCarl, Gowen, and Yeats show that a $100 per ton carbon tax would reduce agricultural-induced welfare by 0.5 percent. We note that this tax level is substantially greater, perhaps as much as ten times greater, than any anticipated carbon tax.

Economic realities—Is agriculture attractive?

Now we come to the question of economic reality. Will agriculture be a player here? Some estimates place compliance costs for some industries at $200–$250 per ton of CO_2. The evidence reviewed above indicates that agriculture could reduce CO_2 emissions or provide CO_2 sinks at a cost of $10–$25 per ton CO_2. These estimates suggest that U.S. nonagricultural industries may approach agriculture to buy emissions reductions or sinks as part of an overall emissions reduction program. The need for reductions may fall with time because of potential



technological developments like fusion-based electrical power which would virtually eliminate CO_2 emissions. However, agriculture may be an important near-term, low-cost emissions reduction alternative. Many agricultural strategies may best serve as a bridge to the future because they, particularly the sink-based strategies such as tillage practice changes, offer one-time gains.

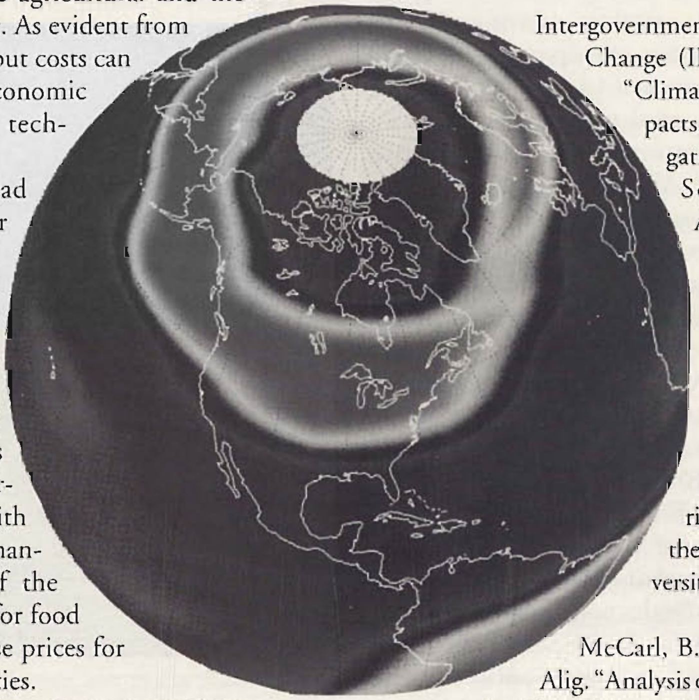
Private property rights and emissions trading

The implementation of tradable carbon permits will alter private property rights. Landowners may loose the right to use carbon-releasing management practices unless they receive or trade carbon permits. The biggest release of agriculturally held soil carbon and biomass occurs when farmers cultivate grasslands or the timber industry harvests undisturbed forests. Thus, an emissions trading scheme is likely to restrict these activities.

Difficulties arise in particular because of the initial land-use status. Will owners of the most degraded agricultural soils experience fewer restrictions but be able to sell the most carbon permits? Will forest owners who never received any payment for the sequestered carbon be able to deforest their lands? Will owners of undisturbed grasslands be able to change land use?

The economics of agriculture under emissions reductions

The economic impacts on agriculture of policies to reduce greenhouse gas emissions depend on the intensity of mitigation efforts, the efficiency of emission markets, and the speed of technological developments, both in the agricultural and the nonagricultural sector. As evident from the past, increased input costs can create considerable economic incentives for new technologies.



Possible widespread adoption of sinks or fuel substitution implies sectoral reallocations. Land devoted to food would decrease under increased production of ethanol, biomass for electricity, and forests. That coupled with restrictions on the management intensity of the remaining land used for food production could raise prices for traditional commodities.

Producers' welfare in the traditional agricultural sector may increase or decrease depending on the degree of production losses and price increases. With inelastic demand for many food commodities, in the short run producers will likely gain and consumers lose. In the longer run consumer losses may be offset by the benefits from reduced global warming. Mitigation efforts will also affect the nontraditional (mitigation) sector. Production of ethanol, biomass for electricity, and wood will increase. Land prices will likely rise as new enterprises compete with existing uses for limited resources.

Besides benefits directly derived from reduced emissions, mitigation may provide additional environmental benefits. Most of the options will also reduce erosion, reduce the use of agricultural chemicals, and could well increase the quality of wildlife habitats. ■

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■ For more information

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