

# **Curbing Greenhouse Gases:**

## **Agriculture's Role**

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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 Kyoto Protocol after the Japanese conference place. Developing 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 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 the gases on an equal footing, the Intergovernmental Panel on Climate Change (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: 20, 100, and 500 years. For example, over a 100-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 farm gate.

### **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 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. For methane reduction, they studied reduced rice fertilization, reduced high-energy feed rations, and a tax on beef consumption. To reduce nitrous oxide emissions, they looked at the costs of cutting nitrogen fertilizer applications. To reduce methane emissions by one million tons, costs ranged from about \$600 per metric ton CH<sub>4</sub> 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<sub>2</sub>O. These costs can be placed on a CO<sub>2</sub> basis by using the IPCC's global warming potential (GWP) for those gases. On a CO<sub>2</sub> basis, the marginal costs are equivalent to \$28 (change in rice fertilization), \$190 (beef tax), and \$15 (nitrous oxide reduction) per ton CO<sub>2</sub>.

### **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<sub>2</sub> 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 marginal costs increase from \$4.50 to \$17 per ton CO<sub>2</sub> 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<sub>2</sub> concentration into the atmosphere because the photosynthetic process of biomass growth removes about 95 percent of CO<sub>2</sub> emitted when burning the biomass. Fossil fuel use, on the other hand, releases 100 percent of the contained CO<sub>2</sub>. 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<sub>2</sub>.

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<sub>2</sub> emission reductions by dividing the cost difference by the amount of CO<sub>2</sub> saved from burning biomass instead of coal. These cost indicators are in the neighborhood of \$10 to \$20 per ton CO<sub>2</sub>.

The economics of ethanol have also been investigated. There has been a rather long history of such things. 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<sub>2</sub>.

### **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 U.S. 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 10 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 placed compliance costs for some industries at \$200-\$250 per ton of CO<sub>2</sub>. The evidence reviewed above indicates that agriculture could reduce CO<sub>2</sub> emissions or provide CO<sub>2</sub> sinks at a cost of \$10-\$25 per ton CO<sub>2</sub>. These estimates suggest U.S. non-agricultural industries may approach agriculture to buy emissions reductions or sinks as part of an overall emission 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<sub>2</sub> 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 lose 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 the initial land use status and its associated carbon levels will impact the level of restrictions. Will owners of the most degraded agricultural soils experience fewest restrictions but be able to sell the most carbon permits from improving carbon levels? Will forest owners who never received any payment for the saved carbon be able to



deforest their lands? Will owners of undisturbed grasslands be able to change land use? Once we start regulating changes in agricultural land use for carbon sink enhancement, how far will we go?

### **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 non-agricultural 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 non-traditional (mitigation) sector. Production of ethanol, biomass for electricity, and wood will increase. Land prices will likely rise as new uses 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.

■ **For more information**

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