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Greenhouse Gas Policy and Canadian Agriculture

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The Issue

To meet its commitment to the Kyoto Protocol (KP), Canada must reduce its current annual GHG emissions (694 MT CO_2 equivalent) by 240 MT CO_2. Canada's agricultural industries have the potential to generate a carbon sink of 10 MT CO_2 (Government of Canada, 2003). The purpose of this article is to consider the manner in which Canadian agricultural policy has responded to Canada's KP commitment and the likelihood that Canadian agriculture will participate significantly in carbon emission trading.

Implications and Conclusions

Proposed changes to agricultural policy are fairly small and focus on encouraging beneficial management practices (BMPs) and verifying carbon sequestration through computer models based on model farms. While agricultural carbon sinks may be included in a national GHG inventory, there is considerable uncertainty as to whether they will be traded in any significant degree in a carbon-offset market.

This uncertainty stems from the basic economics of carbon sequestration. First, carbon-offset prices are expected to remain low, in part because the significant reductions in GHG output that have occurred in Russia and other Eastern Block countries since 1990 can be used to meet worldwide Kyoto reduction requirements, thus limiting demand for carbon reductions from other sources. Demand has also been reduced because of the U.S. withdrawal from the KP. In addition, the Canadian government has proposed a regulated cap of C$15.00 per tonne CO_2 on carbon-offset prices, thus limiting any price increase in the first commitment period. Second, the costs of verification of carbon sequestration may be high. A key factor here is that the scientific link between BMPs and GHG reduction is still unclear. This uncertainty over the impact of BMPs is likely to result in a discounting of the GHG reduction and sequestration that can be claimed, which in turn raises the per unit cost. The low price and high verification costs may mean it is not profitable for farmers to participate in carbon-offset markets, especially when they must consider other issues such as production risk, off-farm income, liability issues and the option value of not being locked into providing permanent credits.

Background and Policy Overview

Canada ratified the Kyoto Protocol (KP) in December 2002, committing itself to a national reduction of 129 MT CO_2 equivalent per year during the 2008–2012 commitment period. Under the agreement, the national inventory of GHG emissions at Environment Canada is expected to be in place by March 2005. This inventory will account for Canada's GHG reductions and sequestrations under the KP, and it will keep track of carbon credits in domestic and international emission trading schemes. Methane and nitrous oxide emissions from enteric fermentation and methodologies for certification will be incorporated into the system at a later stage.

For agriculture, the National Carbon and Greenhouse Gas Emission Accounting and Verification System for Agricultural Land will estimate the amounts and uncertainties of soil carbon stock changes and GHG emissions at the provincial, regional and national levels. The accounting system uses standard methodologies; it incorporates land use and management databases based on ecological models as well as temporal and spatial scaling processes (Agriculture and Agri-food Canada, 2003c).

Under the Action Plan 2000 on Climate Change, Agriculture and Agri-food Canada (AAFC) has been allotted $33 million over five years for programs to address agricultural emissions of GHGs. This funding includes $12 million to be divided amongst the Model Farm Program ($5 million), the Enhanced Shelterbelts Program ($4 million) and the Biofuels Program ($3 million), with the remaining $21 million allocated to the Greenhouse Gas Mitigation Program for Canadian Agriculture (henceforth referred to as the GHG Mitigation Program). The GHG Mitigation Program maintains a goal of reducing agricultural GHG emissions by 5.8 MT per year CO_2 equivalent during the first Kyoto commitment period (Agriculture and Agri-food Canada, 2003a).

One objective of the GHG Mitigation Program is to identify beneficial management practices (BMPs) that can facilitate on-farm GHG emission reduction and enhance carbon sequestration through improvements to soil, nutrient and livestock management practices. Examples of BMPs include carrying out fertilizer formulation and application, livestock feeding, manure handling and soil management in ways that enhance carbon sequestration (Agriculture and Agri-food Canada, 2003a).

The identification of BMPs is critical to the creation of a viable measurement and verification system through the Model Farm Program. The Model Farm Program is a separate program under the Action Plan 2000 on Climate Change and relies on teams of scientists from across the country to measure GHG emissions as a function of Canadian soil, crop and livestock management practices. Their measurements of greenhouse gas fluxes become incorporated into computer models that are then used to estimate net emissions from whole farms. A regional estimate is extrapolated from the resulting data. The reliability of model farms will be evaluated by further measurements at representative farms and research sites in regions across Canada (Agriculture and Agri-food Canada, 2003d).

A GHG mitigation advisory committee will identify, verify, and package the BMPs into "suites" that reduce on-farm GHG emissions and increase carbon sequestration. The program will use demonstrations, communications and training sessions to encourage producers to adopt those BMPs that both reduce GHG emissions and have economic benefits. The advisory committee membership will include research, producer, federal and provincial government, academic and industry expertise and will be supported by a scientific working group comprised of four to five scientists from AAFC and a broader reference group of experts. AAFC is working with the Canadian Cattlemen's Association, the Canadian Pork Council, the Dairy Farmers of Canada and the Soil Conservation Council of Canada, all of which have taken on the responsibility of raising producer awareness regarding GHG mitigation practices (Agriculture and Agri-food Canada, 2004b).

As discussed elsewhere (Fulton et al., forthcoming), farmers have an economic incentive to adopt BMPs in an effort to conserve water and soil organic matter and thereby increase yields and economic returns. Thus, farmers can be expected to adopt BMPs when these practices provide direct economic benefits. In addition, farmers may have an incentive to adopt BMPs in order to participate in the carbon-offset market. The basic idea behind the carbon-offset market is that carbon emitters (e.g., large industrial energy users) who are required to reduce their carbon emissions may decide to purchase a carbon-offset (or carbon reduction) credit from a third party (e.g., agricultural producers) instead of investing in the technology to undertake the carbon reduction themselves (for information on how a carbon-offset market in Canada might function, see Government of Canada, 2003).

Providing that Canada elects to use agricultural sinks to meet a portion of its KP obligations, the BMPs undertaken by farmers – whether to earn direct economic benefits or to participate in the carbon market – will be entered into the national inventory and will be applied against Canada's reduction commitments.[1] The federal inventory is designed to count all reductions and sequestration; while trades will be tracked, this will be done only to facilitate the working of Canada's domestic trading system. The baseline date for the inclusion of GHG reduction projects or carbon sequestration projects that can be reported under the KP is 1990. Only carbon reductions/sequestration that take place in the 2008–2012 commitment period and are associated with projects started after this date are eligible to be counted. The baseline date for projects that can be included in the carbon-trading scheme is 2002. Farmers that began projects after 1990 and before 2002, however, may be able to have their projects included in the carbon-offset market if they participate in a pool.

Canadian Agriculture and the Carbon-offset Market

Whether or not Canadian farmers will choose to participate in the carbon-offset market will depend on the profitability of such involvement. This profitability will depend on the price farmers can expect to receive for sequestered carbon, the costs of sequestering it and the transaction costs of participation. If the expected price is less than the total cost (sequestration plus transaction costs), it is not expected that farmers will participate in the carbon-offset market.

Expected Price

As a number of authors have argued (see, for example, Jotzo and Michaelowa, 2002; Böhringer and Vogt, 2003; Springer, 2003), the expected price of carbon-offsets over the short term is likely to be low. As a consequence, the KP is unlikely to impose substantial compliance costs on the ratifying countries, including Canada. The low expected price is a direct result of the United States not being a signatory to the KP and of the large amount of so-called hot air that is available from the Eastern European economies, where emissions have fallen as a result of decreases in industrial production.

Jotzo and Michaelowa (2002) considered the global carbon-offset market (carbon-offset is treated as a single commodity) after the U.S. withdrawal from the Kyoto Protocol and estimated a price of US$3.78 per tonne CO_2. Their analysis reflects the modifications of the Kyoto Protocol negotiated in November 2001 and known as the Marrakech Accords. The Marrakech Accords accept carbon sinks as a means of carbon reduction within the Annex B countries. (Annex B countries are the 39 emissions-capped industrialized countries and economies in transition listed in Annex B of the Kyoto Protocol.) In their analysis, Jotzo and Michaelowa assume that Annex B countries fully utilize their forest management sink caps for carbon reductions (the accords identify country-specific ceilings for forest sinks). In addition, they assume that Annex B countries commit on

average 10 percent of their agricultural soils to carbon sequestration. In total, sinks are assumed to make up on average 14 percent of the carbon reduction across Annex B countries, while hot air is found to account for 34 percent of total reduction.

Böhringer and Vogt (2003) showed that the introduction of an international carbon-offset market, the non-involvement of the United States in this market and the allowance of sinks all lead to significant reductions in the expected price of carbon. Their analysis also takes into account the impact of the hot air traded by countries of the former Soviet Union. They estimated a marginal abatement cost to the KP signatory countries – and hence an expected price – of US$5.48 per tonne CO_2. A significant portion of this price arises because of the market power that the countries of the former Soviet Union are expected to exert when selling hot air. The authors concluded, as did Grubb et al. (2003), that the KP will not have a significant impact on the signatories in the first negotiation round.

Springer (2003) presented a survey of numerous research studies that examine the impact of the KP. The models he surveyed showed a large variation in prices; with the involvement of the United States in an international carbon-offset market, carbon prices are estimated to be anywhere from US$1.10 to US$24.25 per tonne CO_2, with a median price of US$8.82 per tonne CO_2. If the United States is not included and Russia and the Ukraine are able to exert their monopoly power in the sale of hot air, the estimates are in the range of US$7.71 to US$8.82 per tonne CO_2.

Carbon Sequestration Costs

The principal means by which agriculture is likely to sequester carbon include conservation tillage, reductions in summer fallow, conversion of agricultural land into permanent grass cover, conversion of land into forests (afforestation) and agroforestry. Antle et al. (2001) estimated the marginal cost of sequestering carbon through continuous cropping and the conversion of farmland into permanent cover for dryland grain farmers in Montana to be in the range of US$3.27 to US$136.24 per tonne of CO_2. Their estimate reflects regional characteristics of net carbon yield and opportunity costs and takes into account whether the payment scheme for sequestration is on a per acre or per tonne basis.

Pautsch et al. (2001) estimated the marginal costs associated with the adoption of conservation tillage by Iowa farmers. Their cost estimates range from US$2.72 to US$190.74 per tonne CO_2, depending on the form of payment the farmers receive. One million tonnes of CO_2 sequestration could be achieved with a carbon-offset price of US$51 per tonne CO_2 if payment were based on per tonne sequestered; the cost would rise to US$73.57 per tonne CO_2 if farmers were given a flat fee per acre to adopt no-till.

The Canadian Economic and Emissions Model for Agriculture (CEEMA) predicted significant sequestration levels on the Canadian Prairies through a reduction in summer fallow and an increase in conservation tillage at average carbon-offset prices around C$5.45 per tonne CO_2 (Agriculture and Agri-food Canada, 1999), while Weersink et al.

(2003) found that a carbon-offset price greater than C$40 per tonne CO_2 is required to induce a shift in either crop rotation or tillage system by Ontario farmers.

Using a meta-analysis, Manley et al. (2004) argued that the cost of carbon sequestration on the Prairies is much higher than suggested in the studies cited above. They found that the cost of sequestering carbon at a depth of 25 cm using no-till (compared to conventional tillage) is between US$40 and US$100 per tonne CO_2. Manley et al. pointed out that while some carbon can be sequestered at virtually no cost, the cost is likely to increase rapidly as more carbon is sequestered. They also suggested that the best opportunities for carbon sequestration in soils would be found in the southern United States.

A number of studies have been conducted to estimate the supply of carbon-offset through the conversion of agricultural land to forest plantations. In a review of these studies, Richards and Stokes (2004) estimated that a carbon-offset price of US$2.72 to US$40 per tonne CO_2 could sequester 250–500 million tonnes of carbon annually in the United States and more than 2000 million tonnes globally. Canadian supply estimates from afforestation are within the range of values summarized by Richards and Stokes (2004). In a study published in 1992, van Kooten et al. estimated that for a carbon price between C$2.00 and C$6.25 per tonne CO_2, forest plantations and better forest management could annually sequester 22 and 48 million tonnes CO_2 respectively. The estimated sink levels increase to 3670 million tonnes CO_2 from afforestation in an updated study (van Kooten et al., 2000) for carbon prices up to $14 per tonne CO_2. As McKenney et al. (2004) showed, the costs of sequestering carbon are very sensitive to the assumed growth rate of the forest. For growth rates less than 12 $m^3/h \bullet yr.^{-1}$, only one percent of agricultural land in Canada would be converted to forest at a price of C$50 per tonne CO_2.

Transaction Costs

The cost of sequestering carbon is only one of the costs that affects the likelihood farmers will participate in carbon-offset markets. Also important are the costs of undertaking the transaction to sell carbon credits as well as the costs of administering the system (Stavins, 1995). The transaction costs include the resources required to evaluate and certify the carbon credits as well as any costs related to farmer resistance and/or associated with the mechanism (e.g., contracts) used to encourage farmers to participate in carbon-offset markets (van Kooten, Shaikh and Suchánek, 2002).

In a report prepared for AAFC, the transaction costs associated with evaluating and certifying the credits were estimated to be anywhere between 65 and 85 percent of the total costs (transaction costs plus administrative costs), with the total costs ranging from C$0.37 to nearly C$2.00 per tonne CO_2 (Government of Canada, 2004). These costs, however, have to be viewed as a lower bound to the total transaction and administrative costs that can be expected to exist. For example, van Kooten, Shaikh and Suchánek showed that nearly 75 percent of farmers in the Western Canadian grain belt expressed a

willingness to create carbon sinks if they were adequately compensated, although a much smaller fraction indicated that they would actually be willing to move ahead with the required land use changes. Farmers were particularly unwilling to plant large blocks of trees, and van Kooten, Shaikh and Suchánek suggested that these results indicate that other factors besides the actual cost of sequestering carbon are at work in determining whether a farmer will participate in the carbon market.

Other issues for producers considering the adoption of new BMPs will include production risk, off-farm income, liability and the option value of not becoming locked into providing permanent credits. On this last point, Vercammen (2002) demonstrated that a farmer considering a carbon contract that requires indefinite carbon sequestration would need to be provided with an option value in order to make the contract profitable. This option value functions as a compensation, or premium, for the cost incurred by the farmer when an irreversible decision is made – by signing the contract, the farmer no longer has the option of making other decisions in the future. Vercammen showed that the premium required may be in the order of 60 to 70 percent – that is, the market price would have to be 60 to 70 percent greater than the farmer's costs before the farmer would have sufficient incentive to agree to sequester carbon. In addition to the option value, farmers may require a premium over their costs in order to cover off the risks they perceive they are taking on when they sign the contract.

There are other factors that may raise the transaction costs associated with carbon sequestration. As outlined earlier in this article, Canada's approach to GHG accounting relies heavily on being able to clearly link specific management practices to GHG reductions or carbon sequestration, with aggregate emissions and carbon sequestration determined through the use of computer models associated with different soil, crop and livestock management practices as well as different farming systems. The output of these computer models, however, is only as good as the assumed relationships on which the models are based. Unfortunately, the causal links between specific practices and GHG reduction/carbon sequestration are not well understood in all cases.

While certain management practices, such as minimum tillage of Prairie soils, clearly have the ability to sequester carbon (Desjardins et al., 2004), there is evidence that this linkage does not occur in all locations. In Ontario, for instance, the adoption of minimum tillage does not appear to result in any significant carbon sequestration. As well, uncertainty exists over the coefficients that should be used to convert particular practices into carbon sequestration amounts (Weersink et al., 2003). This uncertainty is very large for N_2O, where very little is known about the connection between management practices and emissions.

Given of this uncertainty, more scientific research is required in order for the relationships between BMPs and GHG reduction and carbon sequestration to be understood. For example, almost no research has been performed on what can be called

the "landscape scale", an area encompassing roughly a dozen farms (Weersink et al., 2003).

If the scientific links between particular management practices and levels of carbon sequestration are uncertain, there will be a discounting of the carbon that can be claimed as having been sequestered. This discounting occurs because of the need for assurance. The larger the degree of uncertainty associated with the amount that is claimed, the more it will be necessary to either sequester a greater amount of carbon or undertake costly monitoring and verification in order to have assurance that a specific amount of carbon is actually sequestered. Discounting thus raises the cost associated with providing carbon-offsets; in short, the discounting of carbon sequestration rates is a transaction cost, since an important component of transaction costs is the monitoring and verification of the amount of carbon that has been sequestered.

These monitoring and verification costs are likely to be important. As the study done for AAFC showed, transaction costs are estimated to be as high as C$18.56 per tonne CO_2 when the monitoring and verification of individual projects is required. When project pooling is allowed, the cost drops to between C$0.10 and $0.20 per tonne CO_2. However, these cost savings can only be achieved if monitoring is kept to a minimum and if certain management practices can be linked to clearly defined amounts of carbon sequestration. If the links between certain management practices (e.g., the BMPs) and greenhouse gas reduction and/or carbon sequestration are not clear, it will not be possible to inexpensively verify that reductions have occurred, and other more costly forms of verification will have to be used.

Discussion and Concluding Remarks

Although agricultural sinks can potentially be included in a carbon-offset trading system, there is considerable uncertainty over whether this will occur. This uncertainty is a result of the underlying economics of the carbon market and of carbon sequestration. While there is some variation in the estimates of the expected price that is likely to exist in the carbon-offset market once the KP takes effect, there is some consensus that the price will be relatively low – e.g., somewhere in the range of US$4.00 to US$5.00 per tonne CO_2. This price would provide sufficient incentive to sequester some carbon in soils, since the marginal cost of the first units of carbon to be sequestered is likely to be close to zero. As the amount of carbon sequestered rises, the marginal cost of sequestration also rises. Depending on the costs of monitoring and verification, and the option values and risk premiums that farmers require, it is unlikely that prices in the range of US$4.00 to US$5.00 per tonne CO_2 will provide sufficient incentive for farmers in Canada to sequester carbon on any significant scale.

Given the anticipated prices and costs, there is a strong likelihood that farmers will not be able to participate individually in the carbon-offset market – the costs associated with monitoring and verification are simply too high. There is, however, some potential

for farmers to participate in the carbon-offset market through pools, providing the monitoring and verification costs can be kept low by linking the BMPs undertaken by farmers in the pool with reductions in GHG emissions or the sequestration of carbon.

If carbon sequestration occurs through pooling, it is likely to be on the Prairies, where the link between carbon sequestration and particular management practices such as no till is relatively well established (although evidence was presented above that this linkage may not be as strong as has been suggested). The much weaker link that exists between BMPs and carbon sequestration in other parts of the country, and between BMPs and GHG emission reductions in virtually all agricultural regions and sectors, means that the monitoring and verification costs for these activities are likely to be substantial, which in turn suggests that they will not be part of the carbon-offset trading system.

Although the cost of carbon sequestration may be lower in activities such as afforestation, there is some evidence that farmers are reluctant to make the investment in what is a relatively unknown practice. The risk premium and the option values required by farmers in these situations are likely to be too large to entice a large-scale change in land use in this direction.

This reluctance may be even greater given the carbon price cap that exists in Canada for the 2008–2012 period. In response to concerns on the part of the large final emitters (LFEs), the Canadian federal government has made a commitment that LFEs will pay no more than C$15.00 per tonne of CO_2 (Christoffersen, 2003). In addition to the risks the cap introduces for the government and the incentives it creates for speculative trades, the cap reduces the expected profitability of carbon sequestration activities by farmers.

If Canada succeeds in having agriculture participate in the carbon-offset market, it will be relatively unique among countries in the world. Australian soil has low potential for carbon sequestration activities in agriculture and therefore provides little demand and supply. In the European Union, agricultural sinks are not eligible for inclusion in the emissions trading scheme. The United States continues to prefer agricultural policies that are designed to support farm income and meet other environmental objectives, such as the Environmental Quality Incentive Program and the Conservation Reserve Program. Nonetheless, a few carbon-offset market transactions involving soil-sequestered carbon have occurred.

Based on the analysis above, the most likely scenario is that during the first commitment period, from 2008–2012, Canadian farmers will participate only to a small extent in the carbon-offset market. Nevertheless, farmers will find it advantageous to adopt many of the BMPs discussed above, since these will generate direct economic benefits in terms of, for example, better water use or the creation of higher quality soil. These BMPs will be counted as part of Canada's inventory of GHG reductions and carbon sequestration. Thus, while agriculture may not participate in the carbon-offset trading system in as significant a fashion as was once anticipated, agriculture will nevertheless make a contribution to meeting Canada's KP commitments.

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Endnote

[1] Canada must decide by late 2006 if it wishes to use soil sinks and/or forest sinks as part of its GHG inventory. If either of these options is incorporated, all related changes in carbon sequestration (positive or negative) will have to be included in Canada's accounting system (Government of Canada, 2003).