AGRICULTURAL SOIL CARBON SINKS AND THE DESIGN OF A DOMESTIC EMISSIONS TRADING SCHEME

by

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Honours B.A., Trent University, 2002

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

The Faculty of Graduate Studies

(Agricultural Economics)

THE UNIVERSITY OF BRITISH COLUMBIA

October 2006

ABSTRACT

After the signing of the Kyoto Protocol and its several mechanisms to reduce greenhouse gas emissions, countries around the globe have been developing appropriate schemes to deal with their excess greenhouse gas emissions. This thesis presents general design guidelines based on the objective of economic efficiency to develop a Domestic Carbon Emissions Trading scheme which also offers to emitters the option of buying offset credits generated from the temporal carbon sequestration services of agricultural soils. Quotas and emissions permits are similar economic instruments and therefore the experience of the Canadian Supply Management system provides lessons and a rich source of rules and procedures for an emissions trading scheme.

Nevertheless, designing a system that manages offset credits generated from sequestering carbon in agricultural soils is not trivial. Through appropriate land management practices the soil can increase its carbon uptake thus reducing the net existence of greenhouse gases in the atmosphere. However, this reduction may not be permanent as carbon sinks (where carbon is stored in the soil) are prone to release the sequestered carbon easily. Given the temporal feature of agricultural soil carbon sinks, this thesis presents relevant design aspects of a Domestic Carbon Emissions Trading scheme which accommodates the unique features of agriculture. In particular this thesis explores the concept of rental contracts which are designed to purchase soil C sequestration services from farmers over a specified period of time to generate the offset credits.

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LIST OF ACRONYMS

ARS	Agricultural Research Service
ASC	Agricultural Soil Carbon
BAU	Business as Usual
CCX	Chicago Climate Exchange
CO_2	Carbon Dioxide
CO_2e	Carbon equivalent
CH_4	Methane
COP	Conference of the Parties
DCET	Domestic Carbon Emissions Trading
GHG(s)	Greenhouse Gas(es)
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
LFE	Large Final Emitters
LULUCF	Land Use, Land-Use Change and Forestry
MMT	Million Metric tonnes
Mt	Megatonnes
N_2O	Nitrous oxide
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture

ACKNOWLEDGEMENTS

I am very grateful for all the support and mentoring I received from my supervisor Richard Barichello. He always offered thoughtful academic comments and a very humane and understanding attitude. I also thank him for having given me the opportunity to learn from him as a research assistant and for letting me be part of this BIOCAP funded project. In the same manner I owe many thanks to Prof. Kathy Baylis who is an inspiring professor full of fresh ideas and energy. Thank you Kathy for all the "micro" tutorials and for all your guidance. Likewise, I want to thank Prof. Gary Bull for his support as part of my Supervisory Committee.

My parents and siblings (mamá, papá, Sue y Hugo) have always been a cornerstone in my life, and I cannot find words to thank them for all their love, faith in me and for giving me the support needed to succeed in this program. And to make my life easier my closest friends Claudia, Caro, Ana, Lia, and Ivalu were always there to cheer me up and remind me the importance of finishing this project. Moreover, I would like to thank Mario, Faride and their daughter for their support, hospitality and for putting up with my stressed out little person during the last stage of this project. Finally, although he just recently became involved in this venture, I want to thank Jacobo for his love and support.

I would like to thank the National Institute of Ecology of Mexico for giving me the time to conclude this project as well as many thanks to my colleagues and friends in Mexico for encouraging me to keep on writing.

1. INTRODUCTION

Agricultural soil carbon sinks[1] can generate greenhouse gas emissions offsets as part of a country's efforts to tackle climate change. However, this reduction may not be permanent as sinks are prone to release the sequestered carbon very easily. Given the nonpermanence[2] feature of agricultural soil carbon sinks, what are the relevant design aspects of a Domestic Carbon Emissions Trading (DCET) scheme if one is to accommodate the unique features of agriculture[3]? Finding a defined set of parameters that address this question is the rationale for this thesis. Research on the role of agricultural soil carbon (ASC) sinks as greenhouse gas emissions offsets is only found in recent literature, and there are still many unknowns that require further investigation. As part of its Kyoto Protocol commitments Canada has lead much of this research and it currently is the only country actively developing a Domestic Emissions Trading scheme, which includes a domestic Offset System (a system where greenhouse gas emissions can be offset by carbon sequestration in the soil). Although several design issues for including carbon sinks in a DCET scheme have been explored by the Canadian government, this study aims to keep these issues as general as possible to offer an alternative perspective.

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[1] Boehm (2003) defines sinks as an activity that transfers carbon from the atmosphere to a reservoir, such as photosynthesis (that is, growth of trees and crops).

[2] The UNFCCC (2002) states that nonpermanence is related to the temporary nature and reversibility of greenhouse gas removals by sinks. Carbon contained in terrestrial ecosystems is vulnerable to natural disturbances such as pest outbreaks, wildfires and diseases, and anthropogenic practices such as harvesting and land management. These disturbances can cause either partial or total loss of the carbon stock from an area that formerly functioned as a sink, thus reversing any environmental benefit resulting from carbon sequestration.

[3] There are two main actions that can sequester carbon in agricultural soils: changes in land management practices and changes in land-use. This study is concerned with changes in land management practices that generate carbon sequestration in agricultural soils, such as tillage practices and nutrient management (that is crop rotation). Changes in land-use may overlap with agro-forestry practices and that is out of the scope of this paper.

Recently, environmental policymakers have been making use of economic instruments to achieve a desired environmental outcome. Such is the case of domestic emissions trading schemes implemented for air pollution control. According to Tietenberg (2000) under this system all sources are required to have permits to emit. Each permit specifies exactly how much the firm is allowed to emit. The permits are fully transferable which means that they can be bought and sold (Tietenberg, 2000). The incumbent control agency gives out the exact number of permits equivalent to the desired emission level. Then a pollution source can meet its emissions reduction obligation by lowering its own emissions (that is by using abatement technology), by purchasing emissions permits from other sources with lower abatement costs, and -in the proposed case- by purchasing emissions offset credits. The major advantage of a system of tradable permits is that both overall emissions control costs and individual net costs of compliance are lower than if each emitter undertook emissions control independently (Edmonds, Scott, Roop, McCraken, 1999). Projects for carbon sequestration in agricultural soils can generate offset credits[4]. However, the temporal nature and reversibility of soil carbon sequestration poses serious challenges for policymakers in the attempt to design policies that incorporate ASC sinks in a DCET scheme. Thus addressing the nonpermanence feature of carbon sequestered in soils is crucial when designing a domestic emissions trading scheme tailored to include this type of emission offsets. In this thesis I propose some alternatives for dealing with the nonpermanence issue of carbon sequestration in agricultural soils supported on the concept of carbon sequestration services rentals from Marland & Sedjo (2003).

[4] Offset credits from ASC sinks are an imperfect substitute for more permanent emissions credits. "Offset credits involve periodic payments for services rendered- that is, the temporary removal of carbon from the atmosphere" (Marland & Sedjo, 2003).

Parties to the Kyoto Protocol have been developing domestic emissions trading schemes as a mechanism to achieve their greenhouse gas (GHG)[5] emissions reduction commitments. Some of these countries are in favour of including agricultural soil carbon sinks as generators of emissions offsets while other jurisdictions have deemed these unsuitable to achieve their GHG emissions reductions. What is the essence of these different standing points? Canada and the European Union (EU) in particular share a clear distinction in the blueprint of their DCET systems. For the first commitment period of their schemes Canada (2008-2012) has decided to include agricultural soil carbon sinks as emissions offsets while the EU (phase 1: 2005-2007) has forthrightly excluded these and any kind of carbon sequestration. The European Union will decide in 2006 whether it will include the use of sinks in the years to follow and currently the German government has shown great interest in studying the potential of sinks (von Velsen-Zerweck, 2004). To gain some insight on these two differing positions I present an exploration of the mentioned emissions trading schemes, while also looking at a voluntary trading system –the Chicago Climate Exchange that in fact trades offset credits generated from ASC sinks.

In designing a system that can assign offset credits from agricultural carbon sequestration it is natural to make use of a framework based on Institutional Economics. In this context, some of the issues that relate to Institutional Economics[6] are: transaction costs, certification of carbon sequestered, the geographical delimitation of the

[5] The Kyoto Protocol specifies the following six greenhouse gases to be included under regulation: CO_2-carbon dioxide, CH_4-methane, N_2O-nitrous oxide, HFCs-hydrofluorocarbons, PCFs-perfluorocarbons, SF_6-sulphur hexafluoride (IETA, 2004)

[6] For a detailed study on the institutional dimensions of an offset system refer to Thomassin (2003).

administering agency, and carbon permit trading. This thesis is an institutional exercise mainly concerned with the latter. Design aspects of a DCET scheme have to be tailored to the peculiar nature of carbon. Butt (2004) suggests that carbon faces issues like being a non-observable commodity, and permanence (which embraces saturation and reversibility). In that same vein Parties to the Kyoto Protocol have highlighted the importance of institutional and legal frameworks intended to minimize risks, specify liability matters, and define property rights and land-tenure related concerns (UNFCCC, 2002).

For the design issues of a DCET scheme I will draw upon lessons learned from the Supply Management system in Canada as in a way quotas and tradable permits are somewhat similar economic instruments. According to Barichello (2002) there are few key characteristics of an efficient emissions permit trading system that have not been used or developed in the supply management regime. The author points out that even though quotas are focused on outputs and emissions permits on inputs, both cases involve an action that generates net income to the recipient. In a general way, quotas and emissions permits both provide restricted access to something that is valuable. Quotas allow access to a market with a more profitable (higher) milk price. Emissions permits allow firms who produce greenhouse gases a potentially cheaper way to deal with them using the permit rather than following a potentially more expensive process of actually reducing their emissions (Barichello, 2002). By looking at some of the main limitations and successes of the Supply Management system I draw some useful lessons for the design of a DCET scheme. Moreover, I present empirical evidence on quota rental behaviour that can guide the policy design for emissions permits and offset credits.

Chapter 2 provides a literature review. Chapter 3 contextualizes the design of a DCET scheme within the Kyoto Protocol mechanisms and looks at the history and role of agricultural soil carbon sinks under Kyoto. This chapter also offers an exploration of selected current developments on emissions trading schemes and their position on ASC sinks, these include Canada, the European Union and the U.S. based Chicago Climate Exchange. Chapter 4 is divided into three parts. Each part addresses different aspects to consider for the design of my proposed DCET scheme. This chapter first studies the economic principles and general features of a DCET scheme; then it addresses issues related to the feasibility of ASC sinks within a DCET scheme. These issues include: Understanding nonpermanence in agriculture; What land management practices can be employed to sequester C in agricultural soils? How do you measure C changes in the soil? What would motivate farmers to adopt these practices? What would determine the price of a tonne of carbon sequestered in agricultural soil carbon sinks? What are the implications of nonpermanence within an agricultural soil carbon sequestration project? The rental contract approach. What are the main pros and cons of ASC sequestration projects? After this I turn to the Supply Management system in Canada which offers lessons for the design of a DCET scheme; this part also includes an empirical exercise that illustrates quota rental behaviour. Chapter 5 puts all of the above issues together and states defined parameters for the design of a DCET scheme that accommodates emissions offsets from ASC sinks. The last part concludes.

2. LITERATURE REVIEW

There are several agricultural and forestry practices that sequester carbon and reduce other GHG emissions. According to the U.S. Environmental Protection Agency (EPAa, 2004) carbon sequestration and reductions of methane (CH_4) and nitrous oxide (N_2O) emissions can occur through several agricultural and forestry practices. By the same token, carbon can be released and CH_4 and N_2O emitted to the atmosphere through a variety of land-use changes and practices. Key forestry practices that sequester or preserve carbon are: Afforestation; Reforestation; Forest preservation or avoided deforestation; and Forest Management (EPAa, 2004). In agriculture there are two main actions that can sequester carbon and generate emissions offsets from agricultural soils: changes in land management practices and changes in land-use. Key agricultural practices that sequester carbon are: Conservation or riparian buffers; Conservation tillage on croplands; Grazing land management; and Biofuel substitution (for a definition of each of these practices refer to Appendix II).

This study is concerned with changes in land management practices that generate carbon sequestration in agricultural soils, such as conservation tillage practices on croplands (that is crop rotation). Changes in land-use may overlap with agro-forestry practices and that is out of the scope of this paper. If the reader is interested in issues related to economics and carbon sequestration in forests it is advisable to read van Kooten *et al.* (1995), and van Kooten *et al.* (1997). To learn more about the comparative role for agricultural and forestry land use and/or management mitigation-based practices and their economic potential refer to the research by Schneider, McCarl, Murray, Williams, & Sands (2001).

Lal *et al.* (1998) indicate that management practices that increase soil carbon (C) include conservation tillage, management of crop residue, cover crops and improved water management. There have been a number of studies which have shown that appropriate land management practices can sequester enough carbon in agricultural soils such that it becomes an alternative to reducing GHG emissions as part of an overall strategy to confront climate change. With regards to the cost effectiveness of carbon sequestration compared with abatement, Stavins (1999) argues that sequestering carbon by planting trees is a potentially cheaper way to reduce GHG emissions than abatement technologies (that is the marginal costs of planting trees is lower than the marginal costs of emission abatement). Furthermore, many authors such as Mitchell *et al.*, Antle *et al.*, and Pautsch *et al.*, assessed the costs and economic potential of carbon sequestration in agricultural soils by changing land management practices. All of these studies show that there is economic potential for carbon sequestration in agricultural soils.

To assess the economic potential of carbon sequestration in agricultural soils the Economic Research Service (ERS) of the U.S. developed a study in 2004 that found that agriculture can provide low-cost opportunities to sequester additional carbon in soils and biomass. The ERS model reports that at a price of $10 per metric tonne for permanently sequestered carbon, 0.4 to 10 megatonnes (Mt) of carbon could be sequestered annually; and at the extreme value, $125 per tonne, 72 to 160 Mt could be sequestered, which is a sufficient amount to offset 4 to 8 percent of gross U.S. emissions of greenhouse gases in

2001 (Lewandrowski, Peters, Jones, House, Sperow, Eve & Paustian, 2004). This model also forecasted that farmers would adopt cropland management (mainly conservation tillage) at $10 per metric tonne permanently sequestered carbon, and would switch land to forest as the price increased to $25 and beyond. In the case of Canada, there must be a reduction of 240 Mt carbon dioxide equivalent[7] (CO_2e) during the first Kyoto Protocol commitment period (2008-2012). In this regard the *Climate Change Plan for Canada* states that agriculture, forests and landfills have the potential to create offset credits for new activities to reduce emissions and increase sinks. The effect of these activities is estimated to represent a reduction of 10 Mt CO_2e for agriculture and 20 Mt for forests (Government of Canada, 2004).

It is worth mentioning that there are entities that question the benefits that soil carbon sinks might bring to developing countries under the Kyoto Protocol, and to governments implementing national emissions trading schemes, such as the European Emission Trading System. Found in a Greenpeace[8] analysis by Meinshaussen and Hare (2003), the NGO calls on all Parties not to use any sink projects for reaching their Kyoto targets for two reasons: "1) credits from sink projects will allow higher fossil fuel related emissions. No political or financial resources must be diverted from the pivotal task of promoting renewable energy sources and energy efficiency, if the aim is to avoid catastrophic climate change"; and "2) the agreement on carbon sequestration does not

[7] Every GHG has a Global Warming Potential (GWP), a measurement of the additional heat/energy which is kept in the Earth's ecosystem through the addition of this gas to the atmosphere. The GWP of a given gas describes its effect on climate change relative to a similar amount of carbon dioxide and is divided into a three-part "time horizon" of twenty, one hundred, and five hundred years. As the base unit, carbon dioxide numeric is 1.0 across each time horizon. This allows the GHGs regulated under the Kyoto Protocol to be converted to the common unit of CO_2e –carbon equivalent (IETA, 2004).

[8] An environmental non-governmental organization (NGO) that has long been opposed to the inclusion of sinks projects under the Clean Development Mechanism of the Kyoto Protocol.

rule out environmentally and socially destructive projects (that is sink projects may manifest by promoting large scale plantations with non-native monocultures, possibly using genetically modified organisms and displacing local inhabitants)". These concerns open up further areas of study, in particular as it relates to social welfare from sink projects. However, such lines of study are beyond the nature of this research and will not be discussed any further.

In terms of economics and policy design issues for soil carbon sequestration in agriculture Antle & Mooney (1999) conclude that the spatial and temporal variability characterizing farm resources and C sequestration are aspects that directly would influence the design, distributional consequences, and information needs of policies to sequester carbon. Antle & Mooney (1999) also conclude that policies based on payments per tonne C, or market based trading, are more efficient than those based on per hectare payments for changes in land management. In that same vein, the ERS model estimated the economic potential to sequester carbon by "factoring into farmers' adoption decisions the trade-off between the additional costs of sequestering practices relative to the additional returns from per tonne carbon payments". Based on this, it was estimated that farmers could sequester up to an additional 28 Mt by adopting conservation tillage on additional lands at the extreme value of $125 per tonne. Thus given its economic potential it is clear that agricultural soil carbon sinks are an attractive option to offset GHG emissions. However, to have the same GHG mitigation value as a unit of carbon emissions reduction[9], a unit of additional carbon sequestration must remain stored in soils or biomass permanently (ERS, 2004). This may be a challenge as the C sequestered in

[9] A Certified C credit is considered equivalent to one ton CO_2e.

sinks might revert back into the atmosphere, feature known as reversibility. An example of a reversal of C previously stored in agricultural soils is when there is a change in land management practices (that is a practice which disturbs the soil). This aspect is related to *nonpermanence* of C in carbon reservoirs. Moreover, nonpermanence can be seen from the saturation point of view. Saturation occurs in carbon offset projects since carbon is stored in the soil at differing rates across time until the soil uptake of C reaches a new equilibrium. These two nonpermanence characteristics (that is reversibility and saturation) have been of much concern in C sequestration research.

The presence of nonpermanence in carbon offset projects carries the need to develop particular policy approaches that would allow the generation and management of emissions offset credits from ASC sinks. Feng, Zhao & Kling (2003) propose three mechanisms to efficiently introduce sequestration into a carbon permit trading market: a pay-as-you-go system, a variable-length contract system and a carbon annuity account system. In the first system, offset credits are assigned to an ASC sink project and the full amount of the C sequestered is paid to the developer/farmer. Liability for any C release falls on the developer; for example, if there is some C released by a cease of conservation tillage practices then the farmer is responsible for purchasing C emissions credits. A variable-length contract would occur through broker arrangements. If a broker wants to buy offset credits from ASC sink projects and sell them to emitters, then she can establish a contract with a farmer so that conservation tillage practices take place for a given period of time (for example during 4 or 5 years). After the fifth year the broker would need to establish a new contract to effectively achieve a permanent reduction in C. Likewise, the Government of Colombia in 2000 introduced at the KP negotiations a similar system to deal with nonpermanence of C sequestration. The carbon annuity system is the most preferred by Feng, *et al.* (2003) and consists of receiving the full amount for the C sequestered in a sink project and putting it straight into an annuity account. The payment put into the annuity account works as a "bond" and as long as the sink keeps effectively sequestering C the owner can access the earnings of the annuity account but not the principal.

Canada proposed another alternative which includes C offsets. This is a system that would provide domestic offset credits for project-based GHG reductions or removals. Emission *reductions* would be generated by projects that decrease the emissions of GHGs from a source through for example managing methane from landfills, thus creating offset credits. Enhancement of carbon sinks in the agriculture and forest sectors would *remove* GHG emissions also creating offset credits. The actual trading of the credits will take place through institutions, such as brokers or exchanges that would be set-up by the private sector, while the role of the government will be focused on overseeing that these credits are not used more than once (Environment Canada, 2005). In this way, the government would make these offset credits available to large final emitters (LFEs) as a key element (not only as an option) of the climate change plan to offset GHG emissions since LFEs will be prohibited from emitting GHGs without an equivalent number of permits. The rules of this system and the administrative basis are expected to be in place by 2006.

This research is supported on an important remark made by Marland, Fruit and Sedjo (2001), which is that permanence of sequestration is *unnecessary* as there is value in delaying emissions regardless of the long term fate of the sequestered carbon. The authors note that although any individual projects may be temporary, the effect of economic incentives for carbon sequestration will be to increase aggregate sequestration on a permanent basis. Marland *et al.* (2001) also discuss economic and environmental reasons (C sequestration delays climate change, buys time for technological progress, buys time for capital turnover, etc.) for which it may be advantageous for some parties to acquire temporary credits and for other to provide these. These authors propose that if emissions reductions are clearly permanent (e.g. fossil fuel is not burned), then emissions credits might be bought and sold. On the other hand, if emissions reductions are not clearly permanent (e.g. carbon is sequestered in agricultural soil), then emissions credits may be rented. In this case what is crucial is to determine who is responsible if and when there is a reversal of sequestered carbon back into the atmosphere. Based on this Marland, *et al.* (2001) propose a rental approach, which is based on the traditional system for limited-term use of a capital asset involving a rental contract. A rental contract can allow the 'buyer/renter' to enjoy the limited term benefits of the asset while the 'seller/host' retains long-term discretion. Moreover, a central feature of this system is that it behaves like a direct credit/debit system which is symmetric and instantaneous (Marland et al., 2001). Credit is assigned when carbon is sequestered and debit when carbon is emitted.

Marland and Sedjo (2003) build on Marland *et al.* (2001) by further exploring the idea that carbon emissions are a liability issue. An emissions credit system provides the means for an emitter to satisfy her carbon liability derived from the firm's release of carbon into the atmosphere. The purpose of carbon emissions credits is to eliminate such liability. Marland *et al.* (2003) note that an issue for C sequestration is the extent to which a carbon offset can be a substitute, perfect or imperfect, for an emissions credit. If carbon offsets are guaranteed as permanent, an offset is a perfect substitute for an emissions credit. To the extent that offsets lack permanence or require higher monitoring and transaction costs, their substitutability becomes less perfect, and this would be reflected in the relative prices determined by the markets. In this way, C offset credits "would rent at a discount to the rental equivalent of permanent credits by virtue of the higher transaction costs, namely periodic transitions and additional monitoring" (Marland & Sedjo, 2003).

To understand the potential rental behaviour of emissions credits[10] this thesis relies on the research by Richard Barichello on farm quotas and their associated discount rates (that is, the observed earnings-price ratios) and rental values. Barichello (2002) compares quotas and emissions permits and argues that these are similar economic instruments although quotas are focused on outputs and emissions permits on inputs. This is derived from the fact that both cases involve an action that generates net income to the recipient or provides restricted access to something that is valuable. In such article, based on an analysis of the Canadian supply management quotas, Barichello recommends several features to manage emissions permits.

Barichello (1996) states that agricultural marketing quotas are used to restrict domestic production hence they become an inelastic input that can have policy rents

[10] Note that the term 'emissions credit' and 'emissions permit' are used interchangeably throughout this document. However, some authors prefer to treat these terms as different concepts. 'Emissions credits' imply some certifying agency has verified that an emissions reduction has occurred, which could be sold in an emissions trading market. On the other hand, 'emissions permits' would only be those assigned to a polluting firm.

capitalized into their value. Although quota rentals are prohibited or discouraged in most Canadian provinces data on quota prices were used to derive an annual return or rental value, which revealed insights into how farm benefits from supply management programs were capitalized into quota prices. Barichello (1996) identified several types of quotas depending upon whether the quota is handled annually or as "permanent" stock. The author says that there are schemes where annual rents are given out and observed, even traded, but never get visibly capitalized into a stock because there are no clear permanent rights to this quota. This situation is used whenever quotas are allocated periodically with no underlying pattern of permanency (Barichello, 1996). Barichello (2000) found that for the period 1995-2000 quota prices increased significantly and the apparent discount rate used in their purchase also changed. In the early 1990s the focus of attention in the quota market would have been the very high discount rates used in their purchase (on average 30% when real private rates of return to capital in developed nations is between 5% and 7%). By the year 2000 the reverse situation applied, the discount rate in the quota market fell quite dramatically. Barichello (2000) reviewed the characteristics, policies and quota market data of this industry and concluded that three changes could have triggered these results: a) the interest rate could have declined; b) the rate of expected capital gains could have increased, and c) policy risk could have fallen. Building on the idea that quotas and tradable permits are comparable economic instruments Wossink & Gardebroek (2005) explored environmental policy uncertainty and marketable permit systems based on evidence form the Dutch phosphate quota program. Such research used the option approach to derive a theoretical model that shows the impact of policy uncertainty on investment in tradable quota. This study found that policy uncertainty could affect the tradable permits market however the effect on the volume of trade remained unknown.

Any of these situations may enlighten the design of a DCET scheme as some policy guidelines can be drafted. In this manner it is ensured that shocks of this nature have a minimal effect on the feasibility of ASC sinks and a market for emissions and offset credits. It is under this scope that quota prices will be examined empirically as a proxy to learn lessons about the potential rental behaviour of emissions credits.

Once the analogy between quotas and emissions permits has been established and the concepts of C emissions and offset credits have been explored, it is now pertinent to look at the framework under which these credits would be managed. As mentioned earlier Barichello (2002) highlights the relevance of Canada's Supply Management quotas for managing domestic emissions permit trading schemes. It is the aim of this research to further develop the ideas presented in Barichello (2002) with regards to the lessons learned from managing quotas, as clearly these can be used to guide the design and implementation of a domestic emissions permit trading regime.

Finally, after the Kyoto Protocol introduction of emissions trading to help industrialized countries in meeting their GHGs emissions reduction commitments governments and academics started studying the possibility of incorporating offsets from sink enhancement activities into DCET schemes. Bull & Harkin (2001) proposed an international forest carbon accounting framework, which is a system for managing, measuring, reporting and trading forest C from an operational to an in international scale that is compatible with the Kyoto Protocol requirements. This framework has three main phases developed in eleven steps. The first phase is entitled 'Design and Evaluation' which presents issues to be considered before a C sink project is implemented. The second phase 'Implementation –Inventory and Management' describes ways in which the C sequestered by a forest carbon project may be reported and managed in order to be efficient. Phase three 'Emissions Trade' presents the steps required to start the trade of forest carbon. The present document borrows some aspects of this framework.

Thomassin (2003) investigated the institutional dimensions of an offset system in the context of Canadian agriculture. This author assertively supports his research on Institutional economic theory which advises that the domestic emissions trading and offset institutions must provide a degree of efficiency and a distribution of benefits and costs that are acceptable to the parties involved.

The present study is an improvement over the existing ones as in order to be widely applicable it has remained as general as possible while becoming the first one to set out a defined set of parameters to incorporate ASC sinks into a DCET scheme, based on the experiences found in the Canadian Supply Management scheme.

3. KYOTO PROTOCOL AND DOMESTIC CARBON EMISSIONS TRADING

It is widely acknowledged that the Earth is suffering from a phenomenon known as global warming, which is to some extent considered to be directly related to the increased atmospheric concentration of anthropogenic emitted greenhouse gases. This climate change occurrence has become of great concern to many countries, and actions to address this situation have been taken, giving place in 1992 to the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC states that: "Each Party shall…limit its anthropogenic emissions of greenhouse gases and protect and enhance its greenhouse gas sinks and reservoirs". In 1997 governments around the globe addressed the public's increasing concern of GHG emissions by adopting the Kyoto Protocol (KP). The Kyoto Protocol requires Annex I countries (for a list of Annex I countries refer to Appendix III) to meet legally binding emission reduction targets. The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5% from 1990 levels in the commitment period 2008-2012 (UNFCCCa, 2004)

A nation can meet its Kyoto Protocol obligations of reducing its GHG emissions through two courses of action: (1) domestically, it can accomplish actual emission reductions at domestic emission sources, and accounting for domestic carbon sinks; and (2) through the use of "flexible mechanisms", which allow a country to acquire additional emission allowances, or annual assigned amounts, from other countries through *International Emissions Trading* (IET) –to be introduced in 2008- or through taking credits for projects that result in emission reductions within industrialized countries through *Joint Implementation* (JI), and *Clean Development Mechanisms* (CDM) in developing countries (OECD, 2002). Thus the recent international interest in GHG emissions trading has mainly derived from the Kyoto Protocol. Discussions on the proposed international trading schemes lead many nations to consider developing their own domestic emissions trading schemes in advance of the entry into force of the Protocol[11]. Among other nations, Canada considered that an early start with domestic trading schemes would allow its industry to take advantage of the inherent potentials of tradable permits for cost-effective emission abatement, and also afford domestic industries the practical experience of "learning by doing" prior to the introduction of international and EU trading schemes (OECD, 2002). On the other hand, many countries considered the possible pitfalls of earlier introduction of DCET schemes, and did preparatory work for a possible domestic scheme, but kept a "wait and see" position until final rules were defined on the international trading schemes under Kyoto (OECD, 2002).

Also, the role of agricultural soil carbon sinks in the design of DCET schemes around the globe has been contentious. The inclusion of sinks under the Kyoto Protocol reflects the complexities of including emissions offsets of this kind. In this section I give an overview of the history of carbon sinks in the development of the Kyoto Protocol negotiations. After this I explore two distinct domestic emission trading schemes, the Canadian one and the Emission Trading Scheme from the European Union (ETS-EU). I will also explore the features of the Chicago Climate Exchange which is a voluntary

[11] According to a UNFCCC press release the ninety-day countdown to the Kyoto Protocol's entry into force was triggered on November 12, 2004 by the receipt of the Russian Federation's instrument of ratification by the United Nations Secretary-General. The Protocol became legally binding on its 129 Parties on February 16th 2005.

GHG emissions reduction and trading pilot programme for emission sources and offset projects in the United States and for offset projects undertaken in Brazil.

3.1 The Kyoto Protocol and the History of Carbon Sinks

The Kyoto Protocol introduced the concept of removal units[12] (widely known as *credits*) from carbon sinks. These credits can be used to meet a country's limitation and emissions reduction commitment (Pautsch, Babcock, Hurley & Campbell, 1999). Carbon sequestered by one Annex I Party could be used to offset emissions in another sector of the nation-wide economy or it could be traded or sold to a Party in another country to use in meeting its national commitments (Marland, McCarl & Schneider, 2000). The KP Article 3.3 states that removals by sinks must result from "direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period". Article 3.4 provides that "...additional human-induced activities related to...removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I". The Conference of the Parties to the Climate Change Convention (COP) has recognized four wide classes of activities under Article 3.4: Forest management; Cropland management; Grazing land management; and Re-vegetation (for a KP definition of each activity see Appendix I). Parties are free to decide which of these activities will aid them meet their

[12] Units recognized under the KP as compliance units for national emissions limitation commitments are: Assigned Amount Units (AAUs), Emission Reduction Units (ERUs) from the Joint Implementation Mechanism, Certified Emission Reductions (CERs) from the Clean Development Mechanism and Removal Units (RMUs) from the effects of carbon sinks.

emission targets, and the selection is then set for the first commitment period (UNFCCCb, 2004). Removals of greenhouse gases from eligible sink activities generate *Removal Units* (RMUs) that Annex I Parties can use to help meet their emission targets. They are only deemed valid, however, once the removals have been verified by expert review teams under the Protocol's reporting and review procedures, and they cannot be banked (e.g. credits cannot be carried over to future commitment periods) (UNFCCCb, 2004). Any emissions from Land Use, Land-Use Change and Forestry (LULUCF) activities, in turn, must be offset by greater emission cuts or removals elsewhere. Let us now take a look at the history of the evolution of these decisions.

Initially, under the KP much of the detail about LULUCF activities was left unresolved and the UNFCCC asked for a special report from the Intergovernmental Panel on Climate Change (IPCC) on several aspects of sinks. The recommendations from this report were included in the negotiation process and most of the more detailed decisions were negotiated at the sixth Conference of the Parties (COP6) to the UNFCCC process and made at the seventh Conference of the Parties (COP7) in Marrakesh (BioCarbonFund, 2003). During these conferences it was agreed to take account of soil carbon sequestration through changes in land management practices. COP7 recognised the above-mentioned classes of activities under Article 3, and the removal unit was created. The IPCC drafted a good practice guidance report for measuring and reporting LULUCF activities ("Good Practice Guidance for Land Use, Land-Use Change and Forestry") based on the COP7 decisions and was presented to the COP9 in Milan on December 2003. The "Good Practice Guidance for LULUCF" elaborates on the existing Revised 1996 IPCC Guidelines for Greenhouse Gas Inventories. According to

Environment Canada (EC) the Good Practice Guidance aims to promote the development of inventories which are transparent, documented, consistent over time, complete, comparable, assessed for uncertainties, subject to quality control and quality assurance, and efficient in the use of resources (EC, 2004). COP10 in December 2004 agreed on and adopted methodologies for adjustments to poor quality sinks emission and removal estimates. Adjustments will be conservative, in the sense that emissions will be adjusted upward and removals and base year emissions will be adjusted downward (EC, 2004).

3.2 Current Developments on Domestic Emissions Trading

The nascent carbon market is composed of both project-based emission reduction transactions (that is where a buyer purchases emission reductions from a project which reduces GHGs emissions compared with what would have happened otherwise) and emissions trading of GHG emission allowances, where allowances are allocated under existing or upcoming cap-and-trade regimes (Lecocq, 2004). By June 2004 several countries/regions had launched a domestic emissions trading programme, including Denmark, the United Kingdom, the European Union, and the New South Wales region of Australia. Also there have been private initiatives with multi-stakeholder partnerships to reduce emissions voluntarily and trade emission reduction allowances and offsets in systems such as the Chicago Climate Exchange and CleanAir Canada (known before as Pilot Emission Reduction Trading -PERT).

The proposed domestic trading schemes vary from one country to another in terms of core design criteria such as sector coverage, permit allocation/crediting methods, etc. (Environment Canada, 2002). For example, the agreements reached in COP6 and

COP7 fully recognized Canada's forest and agricultural sinks and provided clarity in the kinds of activities allowed. On the agricultural side, the package allows countries to account for cropland and grazing land management activities and places no limit on the credits that can be earned (Environment Canada, 2002). The agreement provides an accounting framework for these activities that not only recognizes sinks but also provides credits when farmers are successful in reducing agricultural sources of GHG emissions.

In sharp contrast with the proposed Canadian DCET scheme, the European Union Emission Trading Scheme -which commenced operation in January 2005, has excluded any sink activities from counting as emission reductions at least during the first phase of the EU-ETS (2005-2007). There are many factors that have shaped the EU position on sinks, which may include the involvement of many governments and political agendas, and the difficulty to measure, report, and verify carbon changes across the Union. However, many EU governments and stakeholders (that is the German government and the forestry sector) are pushing for the inclusion of sinks for the second phase of the EU-ETS arguing that they must have as many options to reduce emissions as possible. Assuming that the EU will change its position on sinks by accepting emission reductions projects after 2007, this thesis may offer to EU policy-makers some insight on design criteria needed to include agricultural soil carbon sinks in their emissions trading scheme.

These two systems are examples of national and regional emissions trading schemes pursued by governments. However, there is a very interesting scheme considered to be the "first multi-national and multi-sector market for reducing and trading greenhouse gas emissions" (CCX, 2004), which has favored ASC sequestration activities:

the Chicago Climate Exchange. The CCX is a GHG emission reduction and trading pilot program for emission sources and emission reduction projects in the United States, Canada, Mexico, and Brazil (CCX, 2004). The CCX is a self-regulated exchange designed and governed by its own members. These members have made a voluntary, legally binding commitment to reduce their emissions of greenhouse gases by four percent below the average of their 1998-2001 baseline by 2006 (CCX, 2004).

This section explores in detail design criteria of the Canadian DET scheme, of the European Union scheme and the Chicago Climate Exchange. The objective of this section is to elucidate based on three different perspectives design options and considerations to successfully incorporate agricultural soil carbon sinks into a DCET scheme.

The Canadian Domestic Emissions Trading Scheme

The Climate Change Action Plan for Canada was drafted in 2002 and it established a three-pronged approach to Large Final Emitters (LFEs). The responsibility for creating and implementing a domestic emission trading scheme was assigned to Natural Resources Canada (NRCan), which has been working in close consultations with the industry sector (IETA, 2003). Large Final Emitters include electricity generation, the oil and gas sector, and mining and manufacturing[13]. The approach targets for emission

[13] In particular, LFEs include: oil and gas production, upgrading and refining, pipelines, thermal power generation, mining, steel, aluminium, chemicals and fertilizers, pulp and paper, cement and lime (NRCan, 2004).

reductions of 55 Mt from 2010 "business as usual" (BAU)[14]; access to emissions trading, domestic offsets, and international permits; and complementary measures, including cost-shared investments in innovative technologies to reduce emissions (NRCan, 2004). The following are a set of policy principles that best describe the proposed Canadian DCET scheme, and are found in the NRCan "LFEs Policy Framework" (2004).

Nature: The scheme is a backstop/covenant for Large Final Emitters. LFEs will be prohibited from emitting GHGs without an equivalent number of permits.

Start: The trading program is expected to commence operation in 2008.

Compliance Period: LFEs will be required to quantify and report their GHG emissions on an annual basis.

Links to external systems: The DCET scheme is envisioned to be supported by an Offset system and by trading with other international emissions trading schemes. Only LFEs are required to meet emissions intensity targets and an offset system provides credits for emission reduction or removals not covered elsewhere in the LFEs system.

Targets: Emissions reduction target of 55 megatonnes for LFEs. In Canada there must be a reduction of 240 Mt CO_2e during the first Kyoto Protocol commitment period (2008-2012).

Coverage: LFEs will be required to remit a permit for each tonne of CO_2e they release.

[14] BAU refers to the activities, emissions or removals that would occur in the absence of the proposed emission reduction project or abatement.

Participation: Participation could be open to others; that is public interest groups or the federal government may want to purchase and then retire offset credits.

Allocation: The federal government will allocate permits free of charge from 2008-2012. These permits will be allocated based on emission intensity targets, which means that the exact number of permits a company receives will depend on its level of production. The government will share the financial risk faced by LFEs by ensuring that they are able to purchase permits at $15 per tonne.

Banking: The author has not found any information regarding this issue.

Monitoring and Registry: Permits will be electronic and will reside inside an emission trading registry managed by the government.

Compliance mechanisms: LFE that do not submit permits will be subject to financial penalties.

Observations: The Province of Alberta is home to Canada's petroleum industry and the site of major planned expansions in GHG emitting oil sands processing facilities, and has moved to deal with climate change on a basis which it sees as more compatible with the interest of industries and consumers (IETA, 2003). Alberta is mainly concerned for the potential loss of its industry competitiveness imposed by the KP commitments and advocates for the creation of a long-term commitment to achieving GHG reduction goals rather than participating in the achievement of the KP goals (IETA, 2003). This divided situation poses a serious challenge to the harmonization and well-functioning of Alberta's own emissions reduction strategies and Canada's GHG emission reductions objectives, including the DCET scheme.

Carbon Sinks: The creation of a system of domestic offsets has been recognised as a "made in Canada approach" to complying with the KP emissions reduction commitments (IETA, 2003). Under the Canadian Offset System -expected to be fully operational by 2006 it is envisioned that the government will buy offset credits and make them available to LFEs. Offset credits could either be emission removals or emission reductions. Emission removals result from projects that increase carbon sinks in the agriculture and forest sectors. Emission reductions in the offset system could come from projects that reduce emissions at a source (Environment Canada, 2004). To date no final decision has been made on the inclusion of any sectors beyond agriculture and forests. To deal with the nonpermanence issue of sinks it has been proposed that both temporary and permanent credits would be available to sink proponents. LFE legislation would allow both types of credits to be used for compliance (Environment Canada, 2004). A temporary credit represents storage of 1 tonne of CO_2e for 1 year and a permanent credit represents permanent storage of 1 tonne of CO_2e and liability for replacement if the sink is reversed will be shared between project proponent and government. These permanent offset credits would be interchangeable for international Kyoto units (Environment Canada, 2004). Thus the liability for accidental carbon release for example, relies on taxpayers and to some extent on farmers (or sink project proponents) but farmers have an incentive to participate as they share the risk burden. In the system I propose the market will be as open as possible where farmers and emitters would meet through brokers, although in agreement with the Canadian Offset system it is intended that there be contracts and distinction made on the type of offset credits.

The European Union Emission Trading Scheme

The European Union Emission Trading Scheme is the largest multi-country, multi-sector GHG emission trading scheme world-wide. Combining its size with its institutional complexity, some analysts have referred to the EU-ETS as "the grand policy experiment" for market-based climate mitigation programs (Pew Center on Global Climate Change, 2005). The central characteristics of this system are described below. The information presented was mainly compiled from the International Emissions Trading Association (IETA) trading scheme database, CO2e.com, and from the European Commission webpage for Climate Change.

Nature: The EU-ETS is a cap-and-trade system intended to restrain only CO_2 emissions from industry in the 25 EU-Member States.

Start: The EU-ETS started operation in January 2005. The first phase of the scheme runs from 2005-2007 and after these it will run for 5 year periods, that is, the second phase will go from 2008-2012.

Compliance Period: Allowances corresponding to actual emissions are to be submitted each year, both for the 2005 to 2007 period and the following Kyoto commitment periods.

Links to external systems: Allows companies in the EU-ETS to convert Joint Implementation/Clean Development Mechanism credits into allowances to fulfill their obligations under the EU emissions trading scheme from 2005. All types of JI and CDM credits allowed for use in EU except for: nuclear facilities (excluded by Marrakech Accords), and sinks projects.

Targets: The European Union aims to reduce emissions to 8% below 1990 levels by the end of 2012. A total reduction of 337 Mt CO2 has been committed by the EU during the first KP commitment period.

Coverage: The scheme may be expanded in the future to cover other greenhouse gases, but initially it only covers carbon dioxide.

Participation: The EU-ETS scheme began with five major downstream sectors: power generation, oil refineries, steel, cement and lime, pulp and generation, oil refineries, steel, cement and lime, pulp and paper (covering almost half of EU's emissions of CO_2). Other sectors including the chemicals, aluminium and transport sectors, and emissions of other GHGs may be considered for inclusion at a later date (CO2e.com, 2004).

Allocation: Individual Member State National Allocation Plans for the first phase 2005-2007 were due to be submitted to the Commission by March 31, 2004. For the first phase of the scheme Member States will allocate at least 95% of the allowances free of charge. For the next phase beginning in 2008, Member states will allocate at least 90% of the allowances free of charge. Each allocation plan will contain a list of all installations covered and, more importantly, the quantities of allowances intended to be allocated to each installation for the first phase of the scheme (CO2e.com, 2004). Member States must distribute allowances to installations by February 28th each year. The issue of how to approach allocation to new entrants is to be decided by the individual Member States. The Common Position highlights the need for new entrants to have access to allowances, to ensure growth in the included sectors is not inhibited, but it also recognises that a liquid market in EU allowances should in itself provide adequate access for new entrants (CO2e.com, 2004).

Banking: The life of allowances would be limited to the period for which they are issued, 2005-2007 or 2008-2012. Thus unrestricted banking is allowed within each period. Member States will have the option to allow banking from 2005-2007 into the 2008-2012 period.

Monitoring and Registry: An electronic registry will be created in each Member State. There will be a Competent Authority and a Registry Manager in respect of each Registry. An Allowance will be an electronic unit clearly identifiable as an Allowance by means of an Allowance identifier indicating that it may be used by an Operator to satisfy its compliance obligations under the Community Scheme and capable of being held, transferred and received by any person within the Community who holds an account within the Registry System (CO2e.com, 2004). Note that the public should have access to information relating to the environment, which is held within the Registries System subject to certain restrictions; yearly transaction logs may be made available to the general public, although what exactly they will show (for example, buyer and seller, price, volume etc) is still under discussion. Emissions shall be monitored either by calculation or on the basis of measurement. Operators shall draw up a report for each installation. Emissions from activities in the included sectors shall be subject to an independent verification process on a yearly basis. This will check the validity of the measurements, calculations, emissions factors and related information in the monitoring report. The verifier will need to then issue a further report (CO2e.com, 2004).

Compliance mechanisms: All installations covered by the scheme must hold a GHG permit, or will be liable to financial penalties. During the first phase of the scheme, an excess emissions penalty of Euro 40 (US$50) per tonne of CO_2e emitted shall be levied on all installations who fail to surrender the required number of allowances. A higher penalty of Euro 100 (US$130) per excess tonne of CO_2e emitted will be levied during the second and subsequent phases. In addition to the fines in each phase, any installation that fails to meet its target will have to "make good" the next year – it will have to surrender enough allowances to cover its shortfall from the previous year in addition to the allowances required for the current year (CO2e.com, 2004).

Observations: Certain Member States are not Parties included in Annex B to the KP and so are not permitted to participate directly in international emissions trading as a Party to the KP or to establish a national registry under the KP. However, these Member States are members of the Community and have the same rights and obligations as any other Member State under the Directive. Therefore, special provisions have been suggested to enable the participation of these Non-Annex B Member States in the EU ETS.

Carbon Sinks: Notice that there is no reference to the inclusion of ASC sinks or any kind of C sinks in this system. These in fact have been out for the first phase of the EU-ETS and will be reconsidered in 2006. Why has the EU-ETS excluded ASC sinks to offset C emissions? This decision was mainly supported by *European Climate Change Programme (ECCP) Working Group on Sinks related to Agricultural Soils* (WG Soils), which had the general objective of estimating the carbon sequestration potential of agricultural land in the EU. The agricultural carbon sequestration measures analysed by the WG Soils were those considered under the KP, which are cropland management, irrigation water management, conservation tillage, erosion control practices, grazing management, protected grassland/set-aside, grassland productivity improvements, and fire management in grasslands. The main findings of the WG Soils are found in a report and are discussed here. The estimates provided reflect that there is potential to sequester up to 60-70 Mt CO_2e in agricultural soils of EU-15 during the KP first commitment period (this is a very high estimate compared to the Canadian C sequestration potential from agriculture, 10Mt CO_2e). This amount is equivalent to 19-20% of the total reduction of 337 Mt CO_2e to which the European Union is committed to during that period. Thus the WG Soils agree that there is the potential that soil carbon sinks were used as a suitable measure to help meet the EU's KP commitments. Albeit this conclusion, the WG Soils reported that an analysis of an overall C sequestration potential of particular measures as well as their potential environmental and socio-economic impacts is limited by strong regional differences, which are due to regional variation in soil types and climate. While some soils (e.g. clay soils) accumulate carbon relatively quickly, other (e.g. sandy soils) may accumulate virtually no C even after 100 years of high carbon inputs (ECCP, 2003). Similarly in colder climates, where decomposition is slowed by low temperature, may accumulate carbon more rapidly than soils in warmer climates where decomposition is faster (ECCP, 2003). Analogously do environmental side effects of soil C sequestration measures depend on soil type[15]. Also, in general management practices vary from one region to another. At a European scale insufficient information is available on regional variation in management practices (ECCP, 2003). In this way, the WG Soils report conclude that the overall estimate of the ASC sinks potential is limited by strong regional differences in (1) the sequestration potential of the measure, (2) the environmental impact of a measure, and (3) the socio-economic impact of the measure. The WG also adds that this regional variation prevents a uniform strategy for carbon sequestration across the entire EU and makes a decentralised strategy more promising.

It is worth noticing that the German government gives carbon sinks (from forestry and agriculture) considerable importance and is developing various studies to assess their potential as some researchers believe that there is a high risk of non-compliance with the KP by several Member States (von Velsen-Zerweck, 2004), and C sinks are a viable option to offset emissions.

[15] For example, reduced tillage may lead to problems of weed control under wet conditions, implying high herbicide applications and potential groundwater pollution, while this problem may be less severs in dryer regions. Thus this measure may be not suitable in some regions (ECCP, 2003).

The Chicago Climate Exchange

The CCX is a GHG emission reduction and trading pilot program for emission sources and offset projects in the United States, Canada, Mexico, and Brazil (CCX, 2004). CCX is a self-regulatory, rules-based exchange designed and governed by CCX Members. The development of the Chicago Climate Exchange (CCX) commenced through a feasibility study that was funded by a grant from the Joyce Foundation in May 2000. The grant was managed by Northwestern University's Kellogg Graduate School of Management. The study concluded that a North America private sector pilot GHG trading market is feasible (CCX, 2004). A subsequent grant was given in August 2001 to initiate research on market implementation, which included: preparation of an initial market architecture; formation of a high-level advisory board, and recruitment of industry to contribute to development of market rules (CCX, 2004). According to Le Blanc (2003), the goals of CCX are:

- Proof of concept: establish the viability of a multi-sector GHG emissions cap-and-trade program, supplemented by offsets, to reduce GHG emissions cost-effectively.
- Price discovery and dissemination of market information.
- Standardization of the commodity and building of market infrastructure and institutions— e.g. registry, clearing, settlement.
- Facilitation of trading with low transactions costs.
- Harmonization and integration with other trading regimes.

Nature: The CCX places a voluntary cap and allowances for North American emitters. There are also provisions for project-based offsets including farm and forest sinks, methane destruction and eligible offset projects in the U.S. and Brazil. Under the CCX, there are so-called Tradable Carbon Financial Instruments: CCX Allowances and Offsets.

Start: December 12, 2003. CCX reduction commitments and trading applies for the years 2003 - 2006.

Links to external systems: It would be possible to harmonize the CCX with the KP international emissions trading system as the CCX allowances and offsets are designed to be compatible with the KP units.

Targets: Members have made a voluntary legally binding commitment to reduce their GHG emissions by 1% below baseline during 2003, 2% below baseline during 2004, 3% below baseline during 2005, and 4% below baseline during 2006.

Coverage: Includes all six GHGs using IPCC global warming potentials.

Participation: The founding members are:

Sector	Companies
Environmental Services:	Waste Management, Inc
Pharmaceuticals:	Baxter Healthcare Corporation
Electric Power Generation:	AEP Manitoba Hydro
Semiconductors:	STMicroelectronics
Electronics:	Motorola, Inc.
Municipalities:	City of Chicago

Forest Products Companies:	International Paper MeadWestvaco Corp Temple-Inland Inc Stora Enso North America

Allocation: According to IETA's emissions trading database participants will receive a four-year stream of allowances equalling their agreed emissions level. 2% of the issued allowances are withheld and auctioned in spot and forward auctions.

Banking: Those members that reduce their emissions below the required level can sell surplus emission allowances on the exchange or bank them.

Monitoring and Registry: There is a Registry, an Electronic Trading Platform, and a Financial Clearinghouse.

Compliance mechanisms: CCX has contracted with the National Association of Security Dealers (NASD) to provide regulatory services. The world's leading provider of regulatory services, NASD assists in the registration, market oversight, and compliance procedures for CCX members (CCX, 2004). Each emission baselines and annual emission report is independently reviewed by NASD.

Observations: CCX project-based offsets come from: Landfill and agricultural methane, sequestration in soils and forest biomass. These projects create 3 types of credits: Exchange Soil Offsets (XSOs), Exchange Methane Offsets (XMOs), and Exchange Forestry Offsets (XFOs).

Carbon Sinks: Exchange Soil Offsets arise from carbon sequestration in U.S. agricultural soils. The Iowa Farm Bureau in late 2003 signed an agreement with the CCX to serve as an aggregator of farmers and farmland. The idea is that a price coming through buyers who are parties to the CCX would create an opportunity for farmers primarily in the Midwest US to increase their use of farming practices that result in sequestering more carbon in farm soils (Lynne and Kruse, 2004). The Bureau would bring a price to farmers based on the price negotiated with the buyers of storage through the CCX (Lynne and Kruse, 2004). According to the Iowa Farm Bureau (2004) to be eligible, the land enrolled in the XSO certification program must be capable of being cropped, crops which would need to be produced in a compliant no-till manner. XSOs will be issued at the rate of 0.5 metric tonnes CO_2e per acre per year to farmers who commit to continuous conservation tillage (defined as continuous no-till, strip till or ridge till) on the enrolled land from 2003 through 2006 (Iowa Farm Bureau, 2004). XSOs will also be issued to farmers who commit to maintain soil carbon storage realized as a result of establishment of grass cover plantings on eligible land (land that is capable of being cropped) that were undertaken on or after January 1, 1999. The land must remain in permanent grass cover through 2006. XSOs for these recent grass cover plantings will be issued at a rate of 0.75 metric tonnes CO_2e per acre per year. In the event that the land fails to meet these requirements, all XSOs from such land shall be null and void and any payments for XSOs delivered prior to January 1, 2007 shall be repaid subject to interest and penalties as provided in the sales agreement. This is an annual compliance regime, but there is the requirement of a 20% reserve held until end of pilot project. The transfer price of the XSOs will be the sales price as determined by sale through the CCX less a 10% service fee, and there must be the acknowledgement that CCX verifiers will be given access to fields and CCX documents (to see an example of an XSO Credit Sale Contract and its conditions refer to Appendix IV).

These three developments of emission trading schemes are evidence that soil carbon sinks are an intriguing option for emission reduction commitments. In particular the CCX's Exchange Soil Offset (XSO) system provides a good framework for the inclusion of ASC sinks within a DCET scheme. Some features of the CCX-XSO and of the Canadian Emissions Trading scheme will be incorporated in the design of the DCET scheme proposed in Chapter 4 of this thesis.

After analyzing the Canadian and the European Union emissions trading schemes it is feasible to elucidate why these two world-regions differ in their position regarding C sinks. Given the homogeneity of agricultural practices in Canada and the vast amount of land characterized by somewhat similar geographical and socio-economic conditions, it is easier for Canada to go for sinks by promoting C sequestration land management practices, for example no-tillage. On the other hand, the geographical and socio-economic heterogeneity of the EU (including a myriad of cultural differences and land management practices) becomes a hindrance to designing a strategy to account for C sequestration in agricultural soils. However, the contract option addressed in this thesis does not require a high degree of homogenization across regions as contracts shall clearly delimit the purview of the C sequestration project and the required land-management practice.

ISSUES IN THE DESIGN OF A DOMESTIC EMISSIONS TRADING SCHEME

This section looks at the economics of a domestic emissions trading scheme and shows how emissions trading is an attractive market instrument for environmental regulation. Next the section describes the unique characteristics of agriculture as a carbon sequestering agent and the complexities involved in accounting for carbon changes under a DCET scheme, giving particular attention to the nonpermanence feature and alternatives to deal with it under a DCET scheme. Moreover, this thesis turns to study the Supply Management System in Canada in search of lessons that could aid in the design of a DCET scheme as in a way quotas and tradable permits are similar economic instruments. In this same vein, some lessons are derived empirically from the rental rate behaviour of quotas. These lessons are information on the possible price behaviour of tradable permits and offset credits much needed for effective policy-making and system design.

4.1 General Economic Principles of Emissions Trading

Environmental problems, viewed, from an economic perspective, arise when several actors compete for the same natural resource or environmental benefit, when at the same time these "goods" or the benefits derived from these goods have ill-defined property rights. The lack of clear ownership of these "goods" may lead to their over-exploitation, misuse or general damage as the actor who is reaping the benefits may not have to bear all of the costs of such action. In economics this is known as a negative externality. For example when a firm decides to pollute the atmosphere, this firm gets the profit form selling its product, however, society does not get any of the financial gains and it ends up facing a more contaminated environment. In order to internalize these type of externalities, important economic instruments have been created, in particular Tradable Emissions Permits [16]

According to Petsonk, Dudek & Goffman (1998) properly designed emissions trading programs can:

- Increase environmental effectiveness.
- Reduce compliance costs.
- Create financial rewards for environmental performance.
- Create incentives for new technologies, processes, and environmental management.

To begin the study of the economic principles of emissions trading it is important to establish for the sake of completeness that there are many forms of pollutants trading markets, primarily due to differences in the purview of the scheme and to the products traded. Among these varied forms of emissions trading markets one may find Bubbles, Offsets or Credit-Based Emission Reduction Trading, Cap and Trade programs, Baseline Emission Reduction Trading systems and Rate-based Emissions Trading (CO2e.com, 2004) (for a description of each of these trading markets refer to Appendix V). Tietenberg (1985) suggests that regardless of the pollutant being regulated there are some general economic principles which hold for any emissions trading scheme. However, he also notes that there are some implementation details that depend rather crucially on the

[16] The concept of tradable emissions permits was developed with much detail by J.H. Dales (1968), and first implemented in 1976 in a U.S. air pollution control program.

nature of the pollutant being regulated. Tietenberg (1985) defines three different classes of pollutants: *uniformly mixed assimilative pollutants* (high capacity of the environment to absorb the pollutants relative to the rate of emission, that is volatile organic compounds which do no accumulate over time); *nonuniformly mixed assimilative pollutants* (policy target is specified in terms of a ceiling on the permissible ambient concentration of that pollutant measured at specific receptor locations, that is suspended particles and sulphur dioxide); *uniformly mixed accumulative pollutants* (pollutants which emission rate exceeds the absorption capacity of the environment and thus accumulate over time regardless of the source location, that is greenhouse gases).

Although it is out of the scope of this study to analyse the implications of having differentiated classes of pollutants and a matching emissions trading market it is worth clarifying that this thesis is concerned with designing parameters to fit a Cap and Trade program along with an Offset system for uniformly mixed accumulative pollutants[17].

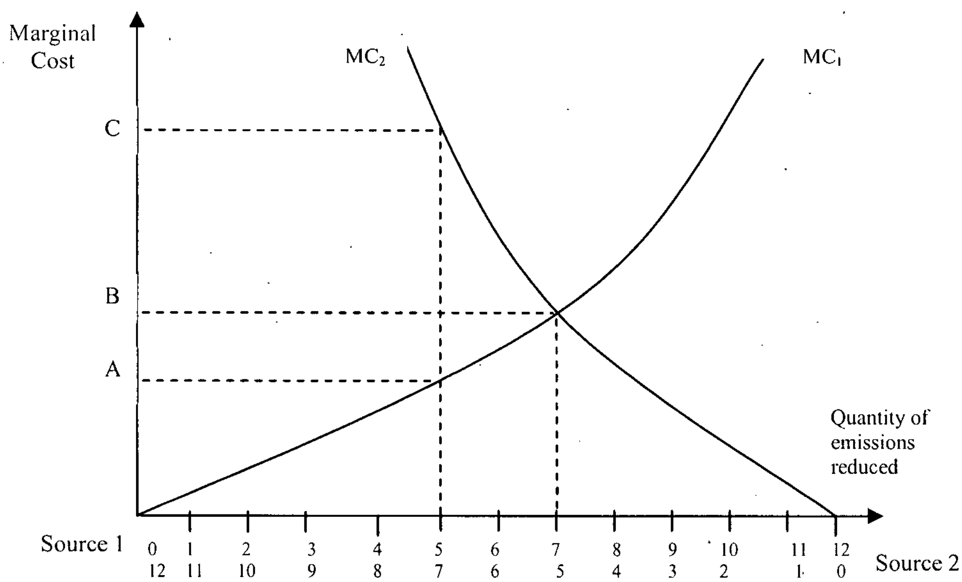
Considering that the main objective of an emissions trading scheme is cost minimization, let us now explore the general economic basis which rule the workings of a properly designed DCET scheme.

After deciding that there must be a reduction in current total emissions, policymakers first place a cap on the amount of emissions to be allowed for each source through a given permit allocation method. The total amount of permits to be assigned will be equal to the targeted amount of emissions reduction. In this way all sources or firms must have a permit to emit. Each permit specifies exactly how much the firm is

[17] Given that the desired domestic emissions trading scheme is intended to regulate carbon and/or carbon equivalent emissions.

allowed to emit, and these permits are fully transferable that is they can be bought and sold (Tietenberg, 2000). Then participating sources will trade in order to meet their individual target. If a firm has an excess of emissions (not enough permits to emit) it may face severe penalties imposed by the regulating agency. In this case, a source can meet its emissions reduction obligation by lowering its own emissions (by using abatement technology), by purchasing emissions permits from other sources with lower abatement costs, and -in the proposed case- by purchasing offset credits generated from carbon sinks. An example of two individual firms participating in a DCET scheme is shown in Figure 1, which is interpreted below (adapted from Tietenberg (2000)).

Figure 1. Individual firms' marginal abatement cost and quantity of emissions reduced.



Source: Adapted from Tietenberg (2000) pg. 350.

Assume that the regulatory agency of Texcoville (an imaginary city) decided that the current 20 units or tonnes of C emitted is a very high amount of pollutants released into the atmosphere, thus it places a cap on emissions. Considering that the desired amount of emissions is 12 tonnes of C (equivalent to a total reduction of 8 tonnes of C), this agency will then assign 12 permits across all sources. Suppose that *Source 1* was assigned 7 permits; since it has 12 units of uncontrolled emissions, this would mean it must control 5 units. In the same way, suppose that *Source 2* has the remaining 5 permits, which means that it would have to reduce its emissions by 7 units. Given that the permits are fully transferable individual firms can trade to meet their obligations. The marginal abatement cost (defined as the increase in the cost of abatement resulting from reducing emissions by an additional unit) for the second source (point C) is substantially higher than that for the first (point A). *Source 2* could lower its cost if it could buy a permit from the first source at a price lower than point C. The first source, meanwhile, would be better off if it could sell a permit for a price higher than point A. Since point C is greater than A, there is place for trade (Tietenberg, 2000). A transfer of permits would take place until the first source had only 5 permits left (and controls 7 units), while the second source had 7 permits (and controls 5 units). At this point, the permit price would equal B, since that is the marginal value of that permit to both sources, and neither source would have any incentive to trade further (Tietenberg, 2000). The permit market would be in equilibrium (Tietenberg, 2000). Simply by issuing the appropriate number of permits and letting the market do the rest the regulating agency can achieve a cost-effective allocation without having even the knowledge about control costs (Tietenberg, 2000).

From the example above it is worth highlighting that there will be no incentive for further trade in permits once the marginal cost of abatement for each emission source is equal to the price of a permit. If a firm has an excess of emissions as long as its marginal abatement costs are higher than the price of the permit, the firm will buy permits. This will happen because it would be very expensive for this firm to produce at a cleaner rate thus the firm rather buy some permits. On the contrary if the marginal abatement cost is lower than the price of the permit, the firm would abate its emissions and sell the surplus permits into the emissions trading market. Moreover, suppose you have a firm that has high marginal abatement costs and it must reduce emissions. As said earlier to achieve this reduction it can either buy permits from another firm of buy credits from a farmer. In this regard it is worth asking the following question: What would lead the firm to buy credits from the farmer as opposed to buying them from a firm? One of the main arguments pro-sinks discussed in the next subsection is that sinks offer a cheaper alternative to deal with emissions thus it is understood that the price for offset credits should be less than the price for emission permits.

The main assumptions under the approach for an emissions trading market are the absence of market power (firms are price takers and do not have the individual power to influence the price of a good by increasing their production), absence of transaction costs (which include costs incurred in searching for and obtaining information, bargaining and decision making in affecting the exchange of a permit), and perfect compliance with the scheme (all firms take as a credible threat the event of facing severe penalties if they do not comply with emissions requirements). However, for most environmental problems these assumptions in reality do not hold and the implications of this should be carefully considered. The presence of transaction costs will lead a profit maximising emission source to estimate its marginal abatement including marginal transaction costs, and equate this with the price of a permit. Given that the transaction cost will not be constant across transactions the market will not settle (Haites & Roberts, 1999). If a trader acquires some degree of market power this may "impose some form of monopoly power where the firm will equate market price with the marginal cost of abatement plus monopoly profit" (Haites & Roberts, 1999).

Thus in the design of an economically efficient DCET scheme it is vital to ensure that transaction costs will be kept to a minimum and that there are strict compliance mechanisms enforced by credible institutions with a clear mandate.

4. APPLICATION TO AGRICULTURE: AGRICULTURAL SOIL CARBON SINKS

Before moving on to the detailed study of the implications of nonpermanence of C in ASC sinks, it is worth noticing that GHG emissions in agriculture can be mitigated by the use of adequate methane and agro-forestry management practices. This thesis has focused on agricultural soils since capturing, measuring and managing C under an emissions trading scheme is not an easy task, and there is much research needed on this topic. However, the tools used here are as applicable as it would be required for methane or forestry projects.

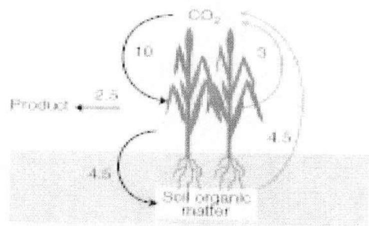
This section explores the following topics: Understanding nonpermanence in agriculture; What land management practices can be employed to sequester C in agricultural soils? How do you measure C changes in the soil? What would motivate farmers to adopt these practices? What would determine the price of a tonne of carbon sequestered in agricultural soil carbon sinks? What are the implications of nonpermanence within an agricultural soil carbon sequestration project and the rental contract approach? What are the main pros and cons of ASC sequestration projects?

5.1 Understanding nonpermanence in agriculture

Soil carbon sequestration is a dynamic cyclical process which poses some challenges for the accurate measurement of its effects on emission reductions. Agriculture has distinctive characteristics when compared to other land uses such as forestry. Farmlands are intensively managed and the time cycle for agricultural crops is short, often annual. Consequently, agriculture can respond quickly to climatic, economic, and policy events by changing land use and cropping systems, and there can be large shifts in just a few years (Janzen, Desjardins, Lemke & Li, 1999). Moreover, agricultural ecosystems are quite "open", involving continual transfer of material in (e.g., fuel, fertilizers, and pesticides) and material out (e.g., crop yields and animal products). Unlike forests, which gradually increase their store of wood, farmlands rarely accumulate vegetation over the long term (Janzen *et al.*,1999).

Figure 2 illustrates a fairly simple model of the dynamics of carbon in agriculture. Carbon absorption occurs through photosynthesis, which is converted into C-containing compounds. Some of this material is used by the plant, a portion is removed through harvest and the rest is returned to the soil. The residue becomes part of the soil organic matter. At this point microorganisms decompose the organic matter to further release CO_2 into the atmosphere and the cycle starts all over again. This cycle is essentially the same in all cropping systems, but rates vary depending on climate, soil, and crop type (Janzen *et al.*,1999). Recall that a sink is any process that removes or transfers CO_2 from the atmosphere to a reservoir. In agriculture, the sink process is photosynthesis, and the reservoir is the soil (Boehm, 2002). If the land is disturbed, then the reservoir is affected, and there would be C released back into the atmosphere, a process known as reversibility.

Figure 2. Conceptual C cycle for corn (values are estimates of annual flows of C in Mg/ha).



Source: AAFC (2005).

Moreover, note that the rate at which C accumulates in the soil due to the implementation of a given land management practice, decreases over time. This means that over time the soil becomes saturated with organic C, phenomenon known as saturation. Due to saturation, the soil will reach a new C equilibrium, and thus annual estimates of the amount of soil C that can be sequestered need to be associated with a time limit. Lal *et al.* (1998) agree that greater soil C increases occur between 5 to 10 years after implementing an improved land management practice, flattening off subsequently and reaching a finite limit after about 50 years.

These unique characteristics of C in agriculture define its nonpermanence feature (store and release pattern). This feature in turn poses some challenges for the estimation of GHG emissions from farms and somehow diffuses the potential role of the agricultural sector as a carbon sink to meet Kyoto targets. However, it is clear that accumulation of organic carbon in soil can occur following changes in management that either increase the production of residue remaining on the field or decrease the loss of organic carbon in the form of carbon dioxide (Marland, West, Schlamadinger & Canella, 2003).

5.2 Land management practices to store carbon in agricultural soils

Management options for sequestering soil organic carbon include a decrease in tillage intensity, a change from continuous to rotation cropping, and a decrease in fallow period (Praustian *et al.*, 2000). Lal, *et al.* (1998) argue that 49% of agricultural carbon sequestration can be achieved by adopting conservation tillage and residue management in the United States. According to Janzen *et al.* (1999) some of the many techniques used by farmers in Canada include:

- Conventional tillage: soils are routinely cultivated to eliminate weeds and prepare soil for seeding.
- Reduced, minimum, or conservation tillage: tillage is reduced to keep residues on the surface.
- No-till: seeds are planted directly without any prior tillage; weeds are controlled by chemicals.
- Summer fallow: no seeding for one season; weeds are controlled by cultivation or by chemicals.
- Increase Forage: increase inclusion of forage crops in grains and oilseed rotations.
- Permanent Cover: involves a shift of marginal cropland to permanent cover with perennial crops.

Using Agriculture and Agri-Food Canada's "Canadian Economic and Emissions Model for Agriculture" (CEEMA), the most recommended agricultural practices for Canada based on their sinks potential turned out to be zero tillage and summer fallow (Boehm, 2003). Based on this Canadian evidence, on the implementation of the CCX-

Exchange Soil Offsets, and on studies mentioned previously (Lal *et al.*,1998), this thesis assumes that zero/conservation tillage is the most recommended practice to reach high C content in agricultural soils (although other land management practices may be as efficient). Although zero/conservation tillage is a good management practice for sink enhancement projects it was previously mentioned that there is large uncertainty about the rate of change of soil organic C in response to the adoption of carbon sequestering farming practices. Some options to measuring C stored in agricultural soils are discussed below.

5.3 Measuring carbon stored in agricultural soils

Measuring the change of carbon in the soil directly is a great endeavour but scientists have developed several options for measuring changes of C content in agricultural soils. This can be accomplished based on climate and soils data and on information on farming practices. When required to measure soil carbon storage in a large geographical area, that is at a country scale, using computer models such as CQESTR and Century is the way to produce scientifically reliable estimates. CQESTR is a very detailed computer model created by scientists of the U.S. Department of Agriculture (USDA) Research Service (ARS). This model allows farmers "to determine short-term carbon gain or loss each year, based on specific management practices [...] also farmers can put together sequences—such as 5 years of no-till, 1 year of conventional till, then 3 more years of no-till—to look at the consequence of changing a practice" (USDA, 2001). This model works for current specific, individual applications on one farm at a time, for the current season. CQESTR became available in early 2001.

The Century model, developed by William J. Parton at Colorado State University in partnership with ARS, "is a more general, long-term plant-soil-nutrient model that links the carbon, phosphorus, and nitrogen cycles and can be used to calculate carbon storage on grass, crop, and forest lands" (USDA, 2001). Century's distinctiveness is that it provides "a comprehensive simulation of carbon dynamics across an entire ecosystem over months and years so it can be used for accurate, long-term assessments of carbon storage under various practices on a regional, national, or global scale (USDA, 2001). This model considers plant responses to soil nitrogen and management practices such as no-till to predict crop yields and levels of soil carbon (USDA, 2001). Moreover, Alamos National Laboratory in New Mexico has developed a prototype instrument called a laser-induced breakdown spectroscope referred to as LIBS. The LIBS technology allows the user to determine soil carbon content at any given point in a few seconds (Lucas, 2002). This technology will allow more efficient verification of soil carbon content, which can be compared to management practices and other data that m ay have affected the amount of carbon being stored (Lucas, 2002).

These and other emerging technologies offer the possibility to measure changes in soil C stock. The proposed DCET will rely on these types of technologies as long as they remain cost-effective.

5.4 Motivation for farmers to adopt these practices

Suppose a farmer has the option of generating offset credits by entering into a contract with an entity that will then sell these credits to a firm that must reduce its GHG emissions. This contract will establish -among other things, the land management practice that should be carried out throughout the duration of the contract. What would motivate this farmer to take the decision of changing her land management practices (for example, changing from conventional to conservation tillage)? This farmer would basically be providing agricultural carbon sequestration services, and would decide to provide such services based on its opportunity cost -where the farm's opportunity cost is the cost to farmers of changing practices. Antle *et al.* (1999) suggest that the farm opportunity cost of providing agricultural sequestration services varies considerably with soil and climate conditions as well as profitability of farm management options. Thus the farmer's decision will depend on the payment made to farmers for changing practices (that is the price per tonne of sequestered C offered by the entity that is negotiating the contract) as compared to the costs to the farmer of changing practices. In this matter, costs to create one tonne of C credit were analysed in a study in Saskatchewan, based on implementation costs of various government sponsored land management programs and the amount of C sequestered as a consequence. These costs ranged from US$6.30 – 18.70 (COP3, 2002). Moreover, as noted by Bull (2006) clean technology (considered in the form of emission reduction units and certified emission reduction units which are Kyoto compliance units) costs up to $100 while offset credits from forest and agriculture projects (considered as verified emission reduction under the KP) costs $5-10. Clearly these prices make offset credits an attractive option for companies wanting to offset their GHG emissions thus generating the demand certainty that would drive farmers to adopt C sequestering practices.

5.5 Determinants of the price of a tonne of C sequestered in ASC sinks

The ERS (2004) model predicted that farmers would adopt conservation tillage at the lowest C price of US$10 per tonne CO_2 sequestered. During late 2005, weighted average prices for agricultural soil carbon credits sold by the CCX were US$2.75 per tonne CO_2. This reflects an inconsistency between the market price for a tonne of C sequestered in ASC sink projects and the price farmers were willing to accept in order to change their current land management practices in order to adopt conservation tillage.

The question of participation is an important determinant for the price that the market will settle: will farmers receive a return for sequestration activities that will compensate them sufficiently for their costs? To address this question other researchers are using budgeting methods. However, in this thesis it is only considered the offset rental value *relative to* the value of permanent carbon credit (earnings/price ratio). Normally, the rental value of a capital item is equivalent to the user cost. Note that in this case, depreciation is not relevant as the key element of user cost is the opportunity cost of capital. Given that the private rate of return to capital in Canada is in the range of 5-7 percent, it should be expected that the rental rate will be at least less than 10 percent of the value of a permanent emissions credit.

5.6 Implications of nonpermanence within an ASC sequestration project

To consider the implications of nonpermanence within an ASC sequestration project let us first recall that nonpermanence implies the reverting of C back into the atmosphere by for example natural disturbances (fires, droughts, flooding) and saturation of C in the soil. Thus the removal of GHG from the atmosphere is temporal in agricultural soil projects. As noted in the previous section agricultural soil C sequestration projects would consist of the use of land management practices which enhance soil C sinks. Under a C emissions trading scheme ASC sequestration projects would potentially generate *offset credits* that temporally reduce overall GHG emissions. In contrast, *Emissions credits* would be considered to permanently eliminate C emissions. This is because credits would generally be generated in the energy sector through a technological change that would decrease the burning of fossil fuels avoiding permanently the release of GHGs into the atmosphere. If a firm emits C into the atmosphere and this firm is capped under an emissions trading scheme, then the emitted GHGs become a C liability. As noted by Marland and Sedjo (2003) liability is the essential issue for permanence. The Kyoto Protocol proposes a scheme "whereby credits against emissions could be achieved by reducing emissions, purchasing emissions permits, or generating offset credits for sequestering C". That is, in a system like this an emitting source can only receive emissions credits if it permanently reduces its emissions (or if the firm buys them) and it would be held liable if this reduction does not occur. However, in the case of ASC sequestration projects, if an offset credit is assigned when C is sequestered, who assumes the liability if the sequestered C is lost? (Marland & Sedjo, 2003) Would the farmer that manages the C project be held liable for lost C or would it be the "buyer" of the offset credits? An alternative to address these questions is developed in the following section.

5.7 The rental contract approach

To address the permanence issue Marland, *et al.* (2001) propose a rental approach, which is based on the traditional system for limited-term use of a capital asset involving a rental contract. Before moving on to the study of the rental contract approach, let us recall that the carbon market is not envisioned to purchase soil C (an asset) from farmers. In agreement with Antle *et al.* (2001) the mentioned contracts will be designed to purchase *soil C sequestration services* from farmers over a specified period of time.

Moreover, Marland and Sedjo (2003) treat C emissions from a liability perspective. Mainly that an emissions credit system provides the means for an emitter to satisfy her carbon liability derived from the firm's release of carbon into the atmosphere. The purpose of C emissions credits is to eliminate such liability. Suppose that a firm has to reduce its emissions (faces a liability issue) and it has two main options, which are to reduce its emissions through abatement technology and/or through entering into a contract with farmers to buy offset credits derived from soil C sequestration services. It is clear that from the nonpermanence of soil C perspective, the emissions offset credits to be bought are a temporal option to "store" the emissions liability as the C sequestered could be released back into the atmosphere. Thus the contract allows the firm to "store" its emissions liability for a limited period of time after which the assignment of offset credits from C sequestration services would cease (since the soil could have reached its C saturation point or simply because farmers would want to change their land management practices) and the firm would have to renew the contract or find some other option to "store" its excess of carbon liability[18]. The point is that the firm will eventually have to reduce permanently its emissions.

The lack of permanence of offset credits implies higher monitoring and transaction costs. Given that the C sequestration is temporal, the ASC sequestration project would require periodic monitoring to make sure that C is indeed being sequestered. This in turn poses higher transaction costs relative to the cost of permanently eliminating emissions (which does not require monitoring over time). Also, ASC sequestration projects have a degree of uncertainty as in any point in time for a given reason the sequestered C may revert back into the atmosphere. Thus in contrast with (permanent) emissions credits, (temporal) offset credits carry a degree of uncertainty and higher monitoring and transaction costs. In this regard, Marland and Sedjo (2003) note that an issue for ASC sequestration projects is the extent to which a carbon offset can be a substitute, perfect or imperfect, for an emissions credit. If carbon offsets are guaranteed as permanent, an offset is a perfect substitute for an emissions credit. Thus the substitutability of offset credits for emissions credits becomes less perfect with the presence of greater uncertainty, transaction[19], and monitoring costs, and this will be reflected in relative prices determined by markets.

Considering that emissions permits are "permanent" and offsets credits "temporal" in a scenario where emissions credits were traded, the market would

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[18] Notice that the length of the contract will have to be suited to the particular land characteristics and management practices as the rate of soil C sequestration directly depends on these factors.

[19] It is known that agricultural programs have traditionally exhibited substantial transactions costs. However, AAFC published a report in 2004 that studied the administration and transaction costs under different potential design scenarios. Their findings suggest that costs are reasonable under all system design scenarios with costs ranging from: 1.54 – 1.74 $/tonne

determine the *value* of a permanent carbon credit (the asset value). This value would provide a base price from which the market could determine the *annual rental values* for C sequestration services (Marland & Sedjo, 2003). That is offset credits would sell at a price equivalent to the annual rental value of an emissions credit.

Let us now look in greater detail some aspects of these transaction costs. First it seems clear that these may be quite large, especially monitoring costs as for example many hectares of land must be inspected to ensure that the agreed C sequestration is achieved. Now, who will bear these costs assuming that this is an open market scheme (particularly no government intervention) where any farmer who wants to rent her sequestration services may do so? Naturally the options are: buyers (firms or any entity interested in buying offset credits) or sellers (farmers). Considering that buyers have several options to reduce their GHG emissions and that offset credits from agriculture represent a very small share of an emissions trading market, the agricultural sector is a price-taker (in C credits), thus buyers will not bear any of these costs. Furthermore, in order to be assured that the ASC sequestration services provided are legitimate, buyers will insist upon third party verification such as that provided by certification firms. This will impose the transaction costs of verification on sellers (farmers), which might negatively affect the net rental value of C offset credits to farmers. In conclusion transaction costs incidence is evident but not quite their magnitude.

Market conditions will be reflected in the proposed rental contracts as these will require information on the price of permanent emissions credits, the discount rate, and other project specific costs. The C sequestration services contract between a farmer and for example a broker, need not be short in duration, it could go from a year to 5 or 10. If longer contracts were required, the "evaluation of future values would probably be discounted, reflecting both the discount rate and the market's assessment of risk" (Marland & Sedjo, 2003).

The rental contract approach is an attractive option in dealing with the nonpermanence feature of C in ASC sinks. On the supply side, contracts offer the flexibility to farmers to manage their land in their best interest and they can choose to not renew a contract in case there is not enough profit in selling C sequestration services. Also the contract approach will have guidelines for addressing the uncertainty, transaction and monitoring costs (for example, the contract might include an insurance clause to deal with phenomena such as a natural disturbance that releases C). On the demand side, since it is not appealing for buyers to pay for something that is temporal the alternative to "rent" emissions credits (that is to buy offset credits) makes economic sense. Now the question is: Would a rental market in credits work well? Will market reflect rationality or only dominated be by speculation? Since the C market is still incipient I will later address these questions based on evidence from the Supply management scheme, in particular, based on empirical evidence of dairy quota rental rates and rental values.

5.7.1 Baseline

An important component of the contract for the rental of C sequestration services is a baseline. Under the contract approach it is useful to establish a baseline which consists of defining the traditional agricultural practise that would have occurred on the landscape where an ASC sequestration project takes place. This baseline is required in order to quantify the amount of C that has been sequestered (or emitted) due to a given land management practice. Changes in C content in the soil should be measured in relation to some baseline or reference. Bull & Harkin (2001) define the baseline C balance as the pattern of GHG emissions and C sequestration that would have been expected to take place on a project site over time without the implementation of the new project. There are several ways to estimate the baseline C balance some of which were discussed in section 5.3[20]. To evaluate the net sequestration[21] of an ASC project there are four criteria that must be met. The net sequestration should be real, measurable, and verifiable. The net sequestration is real if it actually occurs as a result of a specific and identifiable action after accounting for any leakage (discussed below). It is measurable if it can be quantified. It is verifiable if the calculation methodology is acceptable, transparent and replicable (Lemprière, Willcocks, Johnston, Bogdanski, Bisson, Apps Bussler, 2002).

5.7.2 Leakage

Schlamadinger & Marland (2000) define leakage as the unexpected loss of GHG reduction benefits when activities or markets are displaced, resulting in emissions elsewhere. Moreover Marland & Schlamdinger (1997) have showed that carbon sequestration in forest can change the flow of forest products, leading to substitution of alternate products with different energy-intensity, and large implications for the consumption of fossil fuels. Substitution of different products from different sources

[20] It is out of the scope of this paper to further explore this topic. For more information please refer to Bull & Harkin (2001).

[21] Net sequestration is calculated as the C stock change in the with-project case less the C stock change in the baseline or reference (without project) case (Lemprière *et al.*, 2002).

could occur in the agriculture sector, for example if C sequestration efforts changed the productivity of cotton crops (Marland & Schlamdinger, 1997). Here is a list of other possible indirect market impacts identified in Marland & Schlamdinger (1997):

a) use of agricultural lands for carbon sequestration could compete with their use for traditional food and fiber production. The result might be decreased food and fiber production; increased consumer prices for crops, meat and fiber; and decreased export earning from agriculture.
b) Any soil sequestration projects that rely on additional fertilizer can cause substantial offsets in total greenhouse gas emission due to carbon released in fertilizer manufacture and nitrous oxide releases from fertilized fields.
c) Reductions in food production in some countries, due to tradeoffs with carbon programs, might lead to increased agricultural land development through deforestation or grassland conversion in other unregulated countries, leading to higher emission.
d) Increased availability of wood might encourage use of renewable, biomass fuels or development of other new markets for renewable materials.

6. LESSONS FROM THE SUPPLY MANAGEMENT SECTOR

What is the relevance of the Canadian supply management sector for the design of a DCET scheme? Considering that an emissions permit and quotas are similar economic instruments studying some aspects which have made the supply management system (system that administers agricultural production quotas in Canada) efficient is the focus of this section. In accordance with Barichello (2002) production quotas give farmers access to a market with more profitable prices (for example in the dairy sector it gives access to a higher milk price), while emissions permits offer firms a cheaper way to deal with their excess GHG emissions (that is if abating emissions through new technology is more expensive than buying emissions permits, then firms can buy these from other parties). Consequently quotas and emissions permits generate net income in both cases, for farmers and firms. Policies to manage the Supply management sector have been developed and evolving over the past 30 years and as such the system becomes a rich source of lessons to achieve system efficiency.

6.1 Overview of the Supply Management sector in Canada

Canada's agricultural supply management quotas cover the dairy and poultry sectors which account for 20 percent of total farm level sales in Canadian agriculture. The dairy and poultry industries are highly regulated through Marketing Boards, which among other concessions these can control -based on several restrictions- what farmers and producers can produce, and consequently the marketing board can set the domestic price for their corresponding commodity.

According to Barichello (2002) supply marketing boards use two different quota types. One is the farm-level quota that limits how much a farmer's output can be marketed. This quota is defined in terms of a specified number of units of production that can be sold each year into the domestic markets for both fluid and industrial milk. Farm quotas can be bought and sold particularly in the dairy sector and they have no time period attached to them. These quotas are owned and managed by provincial marketing boards. Since industrial milk quotas (or Market Sharing Quota -MSQ) can be used up during any time of the dairy year, there exists the possibility that a farmer could sell quota that is still unused in the current dairy year or quota that has already been used this year. Therefore there are markets for "used" quota and "unused".

Moreover, farm milk prices in Canada are determined domestically given that there are many restrictions on the import of dairy products. Fluid milk price is determined at the provincial level by the marketing boards while the industrial milk price is determined nationally. In general these prices are estimated with formulas that start with a base milk price which is then increased by adding "the costs of primary milk production inputs, such as grain concentrates, forages, labour, and other purchased inputs (Barichello, 2000).

Import quotas (also referred as Tariff Rate Quotas –TRQ) provide a quantitative limit on import access across the different final consumer products within the dairy and poultry industries. These are allotted annually not permanently and they are managed by the Federal Department of Foreign Affairs.

The next section addresses a number of supply management scheme operating rules while emphasising its economic efficiency and thus its relevance with regards to the design of a DCET scheme.

6.2 General System Guidelines for the design of a DCET Scheme

This section suggests general system guidelines for the design of a DCET scheme, which were derived from analyzing the effects on economic efficiency of specific quota allocation and transfer methods. Specifically the general system guidelines put forward below are based on the research by Barichello and Cunningham-Dunlop (1987) in which they describe the characteristics of an *Ideal Scheme for Maximum Economic Efficiency of the Industry*.

Economic Efficiency

In order to achieve maximum economic efficiency first the system would not impose any limitations which increase farm costs; it would have minimum impacts on farm decision-making. This requires that quota transfer rules let farmers decide how to organize, operate, locate and finance their farm at lowest cost and greatest profit, subject to each farm being constrained by a quota (Barichello & Cunningham-Dunlop, 1987). The system should not impose any rules on farmers regarding the type of inputs they can use, the locations where they can farm, the use of different sources of funds or the production of different produce that they would have chosen in the absence of the particular quota transfer rules (Barichello & Cunningham-Dunlop, 1987). From these remarks it can be drawn that system simplicity is key for an efficient DCET scheme, which should have clear and transparent rules with the sole objective of reducing emissions as inexpensively and efficiently as possible. Also, as presented in Barichello (2002) in an efficient system there should be accurate monitoring, verification, and enforcement (in particular for agriculture and ASC sinks). These accurate measures would reduce uncertainty to emissions/offset credits buyers and sellers. Contracts for C sequestration services should be verifiable and operate within a transparent framework.

Administrative Board

Rules should not discriminate among farmers, so that the industry includes only the most efficient, lowest cost producers, each producing at the level she chooses. It is crucial to minimize discretionary decision-making. This requires a degree of regulatory harmonization across regions, and the industry open to new entrants with as few restrictions as possible (Barichello & Cunningham-Dunlop, 1987). This would be accomplished by an open, competitive market for quotas, subject only to Board rules. A rules-based system is more efficient than arbitrary decisions made by the Board as these increase uncertainty.

Initial Allocation & Transferability

Some other lessons derived from the supply management system, which were deemed useful for the design of a DCET system include the crucial remark that any initial allocation of permits is compatible with an efficient system as long as the transfer mechanism is open to all participants. Furthermore, efficiency in the national industry would be achieved if this market for quotas remained opened to farmers from all provinces having a nation-wide composition. Such a large market would also be most likely a competitive market (Barichello & Cunningham-Dunlop, 1987). In terms of the DCET scheme it is thus recommended that there be wide access and competition. That is, there should be relatively unrestricted access to trading by all potential traders, which should face minimum restrictions on trades (permits and offset credits should be fully transferable), while also keeping the trading area for permits as large as possible.

System Issues

Furthermore in an efficient DCET system it is critical to maintain adequate liquidity in the permit trading market. If more permits are required then these can be added through an in-kind tax on permit transfers or annual tax on permit holdings; this will generate an accumulation of permits that could then be auctioned off or offered through a public sale (Barichello, 2002). Note that ASC rentals would add to liquidity on the rent side of the market. Another lesson from the management of quotas in the poultry industry is the way to deal with expected longer-term reductions of quota (Barichello, 2002). If longer-term reductions in permanent emission permits are expected, permits *base level* (or offset credits) should be defined as well as a percentage utilization rate which can be varied annually (e.g., reduced), prior notification (Barichello, 2002). Barichello (2002) also noted that keeping farmers informed through prior notification about the expected quota reductions will maintain uncertainty at its minimum. To keep parties informed and achieve effective price dissemination the exchanges should be registered in an electronic board and there should be open access to this board. Finally, it is recommended that the market remains open to all participants, that is brokers should be allowed.

6.3 Quota Rental Rate and Rental Value Empirical Evidence

Introduction

A very unique feature of this thesis is that it not only uses the lessons derived from the analysis based on economic efficiency of the supply management but it also aims to provide more insights based on empirical evidence found in the estimation of dairy quota rental rates and values. In particular, as the originality of this thesis relies on design issues to manage agricultural soil C offset credits along a DCET scheme some data from the dairy quota sector is used to shed some light on trends that could be expected to occur in the market for emissions and offset credits. The dairy quota prices and rental values were used in this estimation as there are some similarities between quotas and permanent emissions credits (assets), and quota rental values and offset credits (the annual return to the asset). Considering that emissions permits are "permanent" and offsets credits "temporal" in a scenario where emissions credits were traded, the market would determine the *value* of a permanent emissions credit (the asset value). This value would provide a base price from which the market could determine the *annual rental values* for C sequestration services. But would a rental market in credits work well? Will the market reflect rationality or will it only be dominated by speculation? These questions are relevant as for example some argue that quota rental markets are not predictable and rational. Evidence of market rationality is expected to be found by looking at the rental rate and rental values of dairy quotas. In particular, I will test three hypotheses:

1) Do prices reflect costs and returns?

2) Does policy risk matter?

3) Do deadlines or "commitment periods" matter?

As mentioned earlier a rental contract is likely to develop as the main instrument to manage the carbon sequestration services to be provided by farmers. Once farmers enter into contracts with firms where they commit to farm using a given land management practice then a certifying agency will dictate how many offset credits may be assigned for such C sequestration services from farmers. As this C sequestration is potentially temporal (as C may eventually revert back to the atmosphere) it is expected that farmers will receive periodic payments for the services provided (as opposed to a single payment where removal of C would have been permanent). In this case, it can be said that firms will pay farmers a "rent" for letting them "store" for a limited period of time in the cultivated land their excess GHG emissions. In other words, rental contracts allow firms to enjoy annual benefits without assuming capital costs.

Furthermore offset credits are assumed to be an imperfect substitute for emissions credits thus these would not have the same market value. Recalling Marland & Sedjo (2003) the value of an emissions credit would be a base price from which the market could determine the annual rental values for C sequestration services. In addition to this base price the market would consider the transactions costs involved in C sequestration projects such as monitoring and certification. Thus these market conditions will drive rental contracts' arrangements considering the price of permanent emissions credits, the discount rate and other project specific costs. As stated earlier this study looks for evidence that the market for rentals will be rational and not based a pure speculation. To achieve this, this study builds on the research done by Richard Barichello (1996) on farm quotas and their associated rental rates (that is, the observed earnings-price ratios) and rental values.

At this point it is important to define the difference between rental values and rental rates. The rental value is the annual return or benefit to the asset. That is, the rental value is the profit that I make in a year for my ownership of a given asset. For example, imagine that my asset is a house, thus the rental value is equivalent to the profit I make from renting the house in a year. To estimate the permanent value you could also take this annual profit and multiply it by some factor, the most common for houses being 20 or 30. The rental value is the annual profit and you can translate this into the stock value, the capital value, in other words, you can find out in this way how much would it cost to buy the asset in perpetuity. The rental value of a dairy quota (the dairy quota seen as an asset) is influenced by the costs of production but is not influenced by a change in policy for example, as a change in policy will have an effect in the future and the rental value is just annual. On the other hand, the rental rate is the earnings to price ratio of a capital asset. Calculating the ratio of the annual benefit (that is, the rental value) to the quota purchase price measures the rate of discount used to value the quota. The rental rate is influenced by the risk of a change in policy. Why would a policy risk affect the rental rate? The risk comes in because you are looking into the future when you translate the rental value into the value of a permanently owning the asset. This translation must be done with a certain degree of discounting as you are looking into the future. To state this more clearly, how many annual benefits are in the capital value of a stable economy? If there is high risk (could be understood as a change in policy) the capital value is equivalent to 3 years of annual benefit and if there is low risk it is equivalent to 20 years of benefits.

Although quota rentals are prohibited or discouraged[22] in most Canadian provinces data on quota prices were used to derive an annual return or rental value, which revealed insights into how farm benefits from supply management programs were capitalized into quota prices. Just two years ago Alberta commenced a market for quota rentals, thus by the time data were collected for this research information about Alberta's rental market was not available. Barichello (2000) found that for the period 1995-2000 quota prices increased significantly and the apparent discount rate used in their purchase also changed. In the early 1990s the focus of attention in the quota market would have been the very high discount rates used in their purchase (on average 30% when real private rates of return to capital in developed nations is between 5% and 7%). By the year 2000 the reverse situation applied, the discount rate in the quota market fell quite dramatically. Barichello (2000) reviewed the characteristics, policies and quota market data of this industry and concluded that three changes could have triggered these results: a) the interest rate could have declined; b) the rate of expected capital gains could have increased, and c) policy risk could have fallen.

After this background information let us proceed with the model description restating the objective of this section: to find evidence of market rationality by looking at the rental rate and rental values of dairy quotas. In particular, the following three hypotheses will be tested:

1) Do prices reflect costs and returns?

2) Does policy risk matter?

[22] Supply management regimes usually have not allowed rental markets to avoid situation of non-farmers owning quotas, getting the benefits, and farmers only renting.

3) Do deadlines or "commitment periods" matter?

Model description

The interest in the dairy quotas' rental rate arose when Barichello (1996) posed the question of whether there could be capitalization from government program benefits and the evidence was found in the Canadian experience of agricultural marketing quotas. Understanding and measuring capitalization contributes to the always present public policy concern of how much of the share of the benefits of trade protection goes into preserving domestic production and employment and how much goes to economic rents (Barichello, 1996). Agricultural marketing quotas are an effective means of looking for capitalization evidence as all their return is dependent upon government programs. In Canada, atypical high rates of discount were used to capitalize the profits arising from government programs into the asset value (the earnings to price ratio were very high) (Barichello, 1996), and by the year 2000 the discount rate fell as mentioned earlier.

Let us now turn to the construction of the rental rate presented in Barichello, (1996). Calculating the ratio of the annual benefit (that is, the rental value) to the quota purchase price measures the rate of discount used to value the quota. The differences in the prices of unused and used MSQ in the selected months gives this year's return to the industrial milk quota, equivalent to the rental price of MSQ. Using this estimate of the rental price, its ratio to the unused quota price is the earnings-price ratio, or the rate of discount used in capitalizing the quota's benefits:

$$rentalrate = \frac{(unusedprice - usedprice)}{unusedprice}$$

As Barichello's research data presented evidence that the returns to marketing quotas in Canada were discounted heavily by producers trading in these assets there was the need for some model of the farm demand for these quotas. The model developed built on the capital asset pricing model (CAPM) while also adding the concept of policy or default risk presented in Eaton and Gersovitz (1981)[23].

The expected returns from the quota (for example, the annual rent R) are discounted by the real interest rate r, which should include the appropriate premium for systematic risk. This discounting will also include any expectations of future returns to growth or capital gains (the appreciation rate g), where P_Q indicates the asset price of quota and N indicates the expected life of the asset.

$$P_Q = \sum_{t=1}^{N} \left(\frac{R}{(1+r-g)^t} \right) \text{..........(1)}$$

Simplifying because quota is a long-term investment -N gets more distant, the value of quota can be expressed as:

$$P_Q = \left(\frac{R}{r-g} \right) \text{..................(2)}$$

But this formula does not effectively capture the possibility that the rents could be significantly reduced by a change in government policy. The policy risk involved in holding these marketing quotas is the risk that the quotas stream of returns could be stopped or reduced by a change in the policy regime. This risk is manifested in a possible

[23] It is out of the scope of this paper to develop in much detail this model, if the reader wishes to explore more details it is suggested to refer to Barichello (1996).

fall in the expected value of the asset, rather than an increase in the variance of its future returns.

To introduce this risk of policy change to the model, let us define λ as the probability that the quota rents from this policy regime will end. Now the price of the quota becomes an expected value expression. Thus equation (2) which is the discounted rents term is now weighted by the expression its probability (1- λ), and the prospective permanent loss of rents is weighted by its probability λ. Ignoring the discounting factor for simplicity this expression simplifies to:

$$P_Q = \left(\frac{1-\lambda}{r+\lambda-g} \right) R. \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

This model implies that quota prices will increase under four conditions: if there is an increase in annual rents R; a decrease in the real interest rate r; an increase in the expected rate of appreciation of quota values g; a decrease in policy risk λ. As shown in Barichello (2000), equation (3) can be arranged to obtain the "discount rates". Here the rate of discount is R/P_Q expressed in equation (4):

$$R / P_Q = \frac{(r+\lambda-g)}{(1-\lambda)} \ldots\ldots\ldots\ldots (4)$$

Thus the discount rate will decrease with a decrease in r, a decrease in policy risk λ, and an increase in g. This study employs this model to explain the quota rental rate by regressing it on some selected variables. A linear-log model is used which includes the rental rate as the dependent variable, the real interest rate r (coefficient expected to have a positive sign), and given that I do not have an explicit measure of λ I use certain approximations. For example, a dummy variable for policy risk (λ) which takes on the value of 1 for the period before the Uruguay Round Agreement (URA) took effect, that is from 1992-1994 the perception of risk was high (coefficient expected to have a positive sign). There is also a dummy to capture the period after the Uruguay Round Agreement (URA) took effect, that is from 1995-2000 the perception of risk was low (coefficient expected to have a negative sign). And for *g*, the rate of capital gains, there was no good proxy variable. I include a dummy variable for the province of Quebec where it is considered that farmers do not perceive policy risks or they consider them as very low (coefficient expected to have a negative sign). To address the issue of seasonality dummy variables for three separate periods were created using the months of January to March as the base period (September to December is Period 1 and April to July is Period 3).

Summarizing all this, this is how the estimation model for the rental rate looks like. Notice that the model is incomplete as it does not include all variables since I did not have a good proxy for *g*.

Rental $rate_{it}$= $\beta_0 + \beta_1 URA9600_{it} + \beta_2 real\_int\_rate_{it} + \beta_3 dqc_{it} + \beta_4 dp1_{it} + \beta_5 dp3_{it} + \varepsilon_0$

On the other hand a linear-log model is used to present the rental value of quota (the annual benefit of holding the quota) explained by production costs, and an approximation to the milk price, a dummy variable for Quebec and monthly dummies to address seasonality. The signs on the farm costs (cash and non cash costs) coefficients are expected to be negative, the sign on the feed index considered as an input price is expected to be negative. However, the feed index is a heavily weighted component in the formula that is used for determining the industrial milk price. This would mean that if this effect dominates then the feed price index would be expected to be positive. The coefficient on the Quebec dummy is expected to be positive as this would be consistent with the argument that Quebec presents the lowest production costs thereby being the most efficient industrial milk producing province. The coefficient on the dummy variable for the beginning of the dairy year (Period 1) is expected to be negative. This is because at the beginning of the dairy year farmers are under the impression that everything is under control and that they will use up their quota accordingly. However, at the end of the year (Period 3) farmers will start worrying that they might have surplus of milk and might need to buy more quota, then market gets tighter and prices will go up. The dummy variable for Period 3 is expected to have a positive sign because at the end of the dairy year farmers feel under time pressure. This illustrates an interesting intertemporal pricing situation.

Data

Monthly data from the period starting in January 1980 to December 2000 was gathered for four provinces (Ontario, Saskatchewan, British Columbia, Alberta, and Quebec), representing in total over 400 observations. Each observation includes information on the prime interest rate obtained from the Bank of Canada, the industrial milk price, quota exchange prices, and farms' cash costs and noncashcosts, and the feed grain index. The industrial milk implied real price (real price/hL) is a variable that was estimated by dividing the "Total Canadian milk production" by "Farm income from milk sales". Quota exchange prices of unused and used Market Share Quota (MSQ). A dummy variable that equals 1 for the period before the Uruguay Round negotiations took effect (1992-1994), a dummy variable that equals 1 for the period after the Uruguay Round negotiations took effect (1995-2000), a dummy for Quebec, and three dummies to capture seasonality in the dairy year where Dummy for period 1 equals 1 for the months of September to December, Dummy for period 2 represents January to March, and dummy for period 3 marks the end of the dairy year, which equals 1 for the months April to July. Naturally there is no used quota in August because it is the first month of the dairy year. Table 1 provides the summary statistics of the two variables of interest, the rental rate and the rental value. It can be seen that the mean in the rental rate is 26% for this time period, while the rental value shows a mean 9.72.

Table 1. Summary statistics

	Observations	Mean	Standard Deviation	Minimum	Maximum
Rental rate (percentage points)	471	0.2669	0.122	.0058	0.7
Rental Value	471	9.792	14.443	.210	155

Results

Results of the regressions of quota rental rates and rental values are shown in Table 2 and Table 3. Most coefficients turned out significant and in accordance with predictions. Likewise most dummy variables were often in line with the prediction.

(a) Rental rate

The real interest rate coefficient has a positive sign and it is very significant as expected. The dummy variable for policy risk URA9500 shows a statistically significant negative coefficient as it was expected while the dummy for the years before the agreement is positive and very significant. The dummy variable for the province of Quebec is very significant and shows the expected negative sign suggesting that farmers in Quebec do not perceive policy risks or they consider them as very.. The dummy variables for three separate monthly periods are statistically significant and in line with predictions (September to December is Period 1 and April to July is Period 3). These illustrate the seasonal pattern in the dairy year. It is useful to identify this pattern, which supports the hypothesis that deadlines matter. The intercept is also statistically significant.

Now let us link the findings of the rental rate to the potential tendencies in permanent emissions credits. It has been shown that a decrease in the rental rate may be triggered by a change in perceived policy risk, the interest rate and the capital gains. Also it has been noted that for the period 1980-2000 the industrial milk quota rental rate was on average 26%. Could the risk of having such a great rental rate exist in the C emissions credit trading market?

Given that there is already an incipient -although well-functioning emissions trading market it has been observed that there is a considerable demand for C credits, and this market seems to remain unaffected by political concerns or other risk factors. Such is the case of the Chicago Climate Exchange which trades emissions credits in the US without being affected by the fact that the US. has refused to ratify the Kyoto Protocol and thus emissions reductions have not become a national political objective. Thus in this regard it is hard to conclude that the emissions credits rental rates would be in excess of 10 per cent. However, it remains plausible that an increase in the prime interest rate or a decrease in the appreciation rate may boost the rental rate of emissions credits.

(b) Rental value

For model 1 presented in the first column the signs on the farm costs (cash and non cash costs) coefficients were negative and very significant, the sign on the feed index coefficient considered as an input price is indeed negative but not significant. The coefficient on the Quebec dummy is positive and statistically significant and this is consistent with the argument that Quebec presents the lowest production costs thereby being the most efficient industrial milk producing province. The statistically significant coefficient on the dummy variable for the beginning of the dairy year (Period 1) in fact suggests that as compared to period 2 (period 2: January to March) and holding all else constant the rental value for Period 1 will be smaller, as at the start of the winter months profits are lower since costs are higher. The coefficient on the dummy variable for the end of the dairy year (Period 3) is significant and suggests that at this time there is an increment in the rental value compared to period 2, because the market is tighter implying higher prices and greater profitability. The intercept is also statistically significant.

Model 2 included the implied real price but excluded production costs. This model only yielded three statistically significant coefficients (coefficient on the feed index, implied real milk price and the intercept term) which show the expected signs but a very low R^2. The most important feature in this model is that the feed index showed a positive sign which means that holding all else constant an increase in the feed index increases on average the rental value. This may seem counterintuitive if one considers the feed index as a proxy of an input price. However, a plausible explanation is that since feed index is given a very heavy weight in the milk price formula. In this case, the feed index coefficient is expected to be positive just as it turned out to be. The implied real price is coefficient is performing as I would predict. The Quebec dummy is positive which suggests that holding all else constant the rental value in Quebec is higher than in the rest of the provinces, and the seasonal dummies also have the expected signs but they are not statistically significant.

The last column shows the results for Model 3. Since cash and noncash costs are highly correlated variables the coefficient will appear to be more significant, but their explanatory power remains useful. The negative and statistically significant coefficient on cash costs in fact suggests that an increase in cash costs holding all else constant costs leads to a decrease in the rental value as expected. Moreover, in this model holding all else constant an increase in the feed index leads to an decrease in the rental value (but this coefficient is not statistically significant). The Quebec dummy once again is positive and significant which suggests that holding all else constant the rental value in Quebec is higher than in the rest of the provinces. Finally, the seasonal dummies for Period 1 and Period 3 show the expected signs and are statistically significant (at the 1% and 5% level respectively).

There was evidence indicating that the residuals were heteroskedastic. To correct for this, a heteroskedasticity robust standard errors procedure was used. Also the correlation matrix in Table 4 indicates that the variables cash costs and noncash costs were highly correlated thus the specification for the rental value model had to be modified. However, in the model in the first column of Table 3 these two variables were included, while they were excluded from the other two models.

Now let us relate the findings of the rental value to the potential tendencies in the rental contract approach and offset credits, recalling that an offset credit would be "rented" at a discount to the rental equivalent of permanent emissions credits. The main lessons derived from this analysis is that provinces which are more efficient in sequestering C would be able to sell their services at lower costs, and these provinces will attract most contracts. Also the price of the offset credits will certainly be affected by the production costs of the specific land management practices, if the price of an input increases, the offset credits will definitely reflect this price. Moreover it was interesting to note the seasonal effects which are very much present in an agricultural cycle. Thus the price of an offset credit may vary depending on the time of the year in which is sold and this consideration and its implications must be reflected in the contract.

Table 2. Rental rate model

	coefficient	t-stat
Constant	-0.076 (0.046)	-1.65
URA9500	-0.030 (0.015)	-1.99
URA9294	0.085 (0.019)	4.48
Real_interest_rate	0.171 (0.020)	8.73
Dummy for Quebec	-0.034 (0.010)	-3.23
Dummy for period 1 (Sept to December)	-0.029 (.012)	-2.43
Dummy for period 3 (April to June/July)	0.00001 (0.010)	0.07
R^2	0.3773	
Number of Observations	471	

NOTES: standard errors provided in parentheses.

Table 3. Rental value model

	Rental value: Model 1		Rental value: Model 2		Rental value: Model 3	
	coefficient	t-stat	coefficient	t-stat	coefficient	t-stat
Constant	75.601 (9.10)	7.57	-78.006 (25.577)	-3.05	75.049 (12.394)	6.06
Cash costs	-23.433 (3.489)	-6.72	....	....	-23.430 (2.571)	-9.12
Non cash costs	-13.518 (2.119)	-6.38	....	....	-13.539 (2.130)	-6.36
Feed Index	-0.279 (0.508)	-0.55	6.234 (1.264)	4.93	-0.290 (0.461)	-0.63
Implied real price	....	....	15.495 (6.212)	2.49	0.162 (2.990)	0.05
Dummy Quebec	1.260 (0.531)	2.37	0.5874992 (1.422)	0.41	1.25341 (0.444)	2.83
Dummy period 1 (September to December)	-2.308 (0.509)	-4.54	-2.553 (1.436)	-1.78	-2.307 (0.462)	-4.99
Dummy period 3 (April to July)	0.943 (0.477)	1.98	0.568 (1.366)	0.42	0.943 (0.509)	1.85
R^2	0.2922		0.0911		0.2922	
Number of Observations	245		403		245	

NOTES: standard errors provided in parentheses.

It is important to bear in mind that the rental rate and the rental value models are incomplete as there are many variables missing, and that also some of the data might be measured with error. Albeit these limitations this analysis remains useful to illustrate systematic factors.

<u>Discussion of results</u>

Using monthly data for four provinces and the differences in the prices of unused and used MSQ months, the rental value of industrial milk quotas was estimated. The ratio of this rental value to the quota purchase price measured the rate of discount used to value the quota. Form this analysis it can be concluded that market for quota rentals is rational. The rental rate and rental value variables were regressed and the results favourably supported the three initial hypothesis: prices reflect costs and returns; policy risk matters, and deadlines or "commitment periods" matter. This analysis shows that rental values on average vary in a systematic and economically rational fashion. The values show that they do behave with a pattern of predictability. Therefore permanent emissions credit and offset credits rental markets are expected to behave accordingly. Before moving on to the next section it is important to mention that even though the rental value was measured using an indirect variable (since I had no real rental values) it still gave reliable econometric results. The models fitted nicely buy it is suggested that once there is available information on the quota rental markets to try this same exercise and build on this findings.

7. DESIGN CRITERIA OF A DOMESTIC EMISSIONS TRADING SCHEME

Given the nonpermanence feature of C in agricultural soil carbon sinks, this section describes the relevant design aspects of a Domestic Carbon Emissions Trading scheme that accommodates the unique features of agriculture. The departing point is to envision a DCET in which there are at least two participating sectors: one that is GHG emissions capped and another one that can offer emissions removals or offsets. Then - based on Tietenberg (2000) there would be a cap placed on the amount of emissions to be allowed for each source of a given sector based on an allocation method, and sources will trade among themselves in order to meet their individual target. Under this system all sources are required to have permits to emit. Each permit specifies exactly how much the firm is allowed to emit. The permits are fully transferable which means that they can be bought and sold (Tietenberg, 2000). The incumbent control agency gives out the exact number of permits equivalent to the desired emission level. Then a pollution source can meet its emissions reduction obligation by lowering its own emissions (for example, by using abatement technology), by purchasing emissions permits from other sources with lower abatement costs, and -in the proposed case- by purchasing carbon offset credits generated from carbon sinks.

To gain access to offset credits, a firm can address a broker to enter into a carbon sequestration services contract with farmers. The broker will contact interested farmers and offer a price set in the C market along with the firm for the offset credits generated through C sequestration services. In this contract farmers commit to practicing certain land management practices that depending on the soil type and crop will sequester an agreed amount of C. Note that farmers would commit to practice, for example no-tillage in a given area of land for a (t) period of time, where at some point after adequate monitoring and verification, an agency can assign offset credits for the C sequestered in those lands. The unit of sequestered C would be a tonne. An offset credit would be equivalent to a tonne of C sequestered. At the end of the contract the firm who was renting the sequestration services may renew the contract or must look for another place where to "store" its emissions; or in the best case scenario, it would not need to store these anywhere else (that is buying offset credits) as it had achieved a permanent reduction in its emissions. Under the rental contract approach farmers are accepting responsibility for the emission during a finite term, and at the end of that term the renter faces the liability for emissions unless the carbon remains sequestered and the lease is renewed (Marland and Sedjo, 2003).

This alternative differs to that offered under the Canadian DCET scheme in the way that the liability of certified sequestration projects under the Canadian DCET scheme would be assumed and guaranteed by the government, not by a broker/company that would best perform this activity. The government would be the only buyer of the offset credits, which in turn would make available to the Large Final Emitters as a substitute for emissions permits. This also implies that the government would be responsible for guaranteeing the offset sequestration permanency, and overall it is foreseen that a system like this might be too costly in terms of transaction costs, such as those involved in administration, monitoring and verification. The rental contract approach leaves the door open to reach efficiency by allowing the best suited companies and farmers to participate in the C market and the trading of offset credits. Based on the previous analyses of quotas and existing domestic emissions trading systems what follows are the general system guidelines for the design of a domestic carbon emissions trading scheme and the inclusion of agricultural soil C offsets.

5.1 Economic Efficiency

A central element in the case for using market-based instruments in preference to command and control regulation in environmental policy is static efficiency (or cost effectiveness) in achieving a given level of abatement, in other words, reducing aggregate abatement costs by switching abatement to firms which can reduce pollution at least cost or by temporarily storing the excess GHG emissions in ASC sinks.

It is vital that the proposed DCET scheme minimizes transaction costs by keeping rules simple, by not imposing more regulations than needed, and through ease of transferability. Also for the sake of economic efficiency the DCET must reduce uncertainty to permit/offset buyers and sellers. Successful domestic trading of carbon credits between agriculture and industry and also within industry will require contracts for carbon that are fungible, verifiable and operate within a framework that is transparent, consistently applied and holds parties accountable for their claims (Petsonk, Dudek and Goffman, 1998). There should also be adequate monitoring, verification, and enforcement; as well as transparency in trading rules, prices, etc.

5.2 Initial Allocation

Initial allocation of permits does not matter as long as there is low-cost, legal transferability.

5.3 Transferability

There must be full transferability between buyers and sellers of both emissions and offset (permanent and temporal) credits.

5.4 System Issues

As presented in Barichello (2002) relevant system issues include:

- How to reduce stock of DCET permits? The Supply Management regime presents an example for this. First it defines a base emissions level and applies a "utilization rate" every year.

- How to ensure adequate market liquidity? A market can be described as liquid if it has sufficient volume on both the bid and offer sides of the market such that an average trade size does not significantly move the market price (UK-Emissions Trading, 2002). Therefore, the numbers of buyers and sellers and the frequency with which they trade, the average volume of trades, and the stability of the market price are important parameters. As an aid to reaching a liquid market, it is important that information is effectively disseminated between market participants. There should be a registry electronic board which would contain information on all the trading accounts that have been opened along with contact details for the account holders. Price information should be available on brokers websites just as in the supply management system. (UK-Emissions Trading, 2002).

5.5 Administrative Board

Learnt from Canada's Supply Management System one should minimize discretionary decision-making. A rules-based system is more efficient than arbitrary decisions made by the Board. The more power you give to the board the more one would violate the minimization of uncertainty under the DCET system, which for example could affect transferability, a basic component that ensures cost-minimization and efficiency.

5.6 Property Rights

There has been much concern over property rights over ASC sequestration projects and offsets credits. The concern mainly arose when imagining a hypothetical situation in which a farmer is granted offset credits for the hectares of land under which she is practicing C sequestration friendly land management practices. Is the owner of the offset credits the farmer or the firm that eventually buys these from the farmer, and how can a firm claim that "owns" so much C stored in a piece of land that is not their own? This question is not applicable within the rental contract approach as in this case carbon is not treated as a commodity; in fact, what is being rented is the services rendered not the C sequestered *per se*. Under the rental contract approach it would not make sense to ask: Is the owner of the offset credits the farmer or the firm that eventually rents the C sequestration services from the farmer?

However, there might be some conditions under which ownership is in question. For example, when the government assigns offset credits to a region where many farms practicing no-tillage are located, and then offers these credits for sale to emissions capped firms. Here the government creates and decides whom to sell the offset credits and it places restrictions on the production decisions of farmers, would these offset credits belong to farmers or to the government? The issue of property rights is a very contentious one that I would like to address with discretion and I suggest the reader to refer to more detailed research in this topic[24].

5.7 Final Remarks: General Design Criteria

In accordance with the design criteria framework used in Section 3.2 to explore current developments on domestic emissions trading, what follows is the design criteria of the proposed DCET system which includes an open-market Offset System. When

[24] For more information on legal implications of agricultural soil carbon sinks it is recommended to read "Carbon Sequestration in Agricultural Soils" in Biocap-Brief. The BIOCAP Canada Foundation. Issue 5, April 2004.

applicable, each feature will have a dual interpretation, one that applies to emission sources and emission permits, and the other that refers to farmers and offset credits.

Nature: Voluntary in the offset market compulsory for Large Final Emitters. The DCET and offset scheme will be valid nationwide as this is a way to include as many participants in the market as possible. Similar to the quota system, there will be a federal authority that overviews the works of the DCET scheme but each province is allowed to accommodate certain regulations in order to administer the DCET scheme.

Compliance Period: It is proposed to be on an annual basis. The emissions sources will render their emissions reduction accounts every year.

Links to external systems: The DCET should be compatible to the extent possible with the KP proposed international emissions trading regime for the trading of emissions credits. On the other hand, offset credits from agricultural soil carbon sequestration is expected to be a more domestic regime as first the use of ASC sinks is not allowed under the KP. Second, monitoring the effectiveness of the C sequestering services and the legal basis for the contracts would be difficult to administer across borders.

Targets: The suggested national targets in accordance with the goals for each commitment period.

Coverage: The gases will be those included under the Kyoto Protocol, which include six main greenhouse gases and the permits will be the carbon equivalent to each.

Participation: Participants will be the main pollution sources (for the permit market and farmers for the offset credit market (this could be expanded to include the generators of clean energy and communities managing their forest with LULUCF recommended practices) DCET scheme. There has been some discussion about including consumers.

Allocation: The initial allocation will not matter and Pareto Optimality will be met as long as there is transferability. An initial combination of auctioning and grandfathering will work well as the first one facilitates entrant to the market and the second form of allocation is generally well accepted by the regulated parties.

Banking: Banking of emissions permits is allowed. The accumulated permits can be sold later through and auction or public sale.

Monitoring and Registry: The registry of the trading will be posted on an electronic board accessible to participants.

Compliance mechanisms: A transfer institution such as a Permit exchange will be supervised by government agency. On the other hand, to deal with the offset credit contracts it is expected that there will be an evolution of a system of brokers which will be market driven and these will work in conjunction with verification agencies (certification companies).

Observations: It is important to keep market participants informed of the current C price so they can learn from each transaction. In the case of quotas farmers placed a bid but never learned what price was the one that got them to realize the transaction in case they had met the price for the quota. The market in consequence turned rough and it is better to have price transparency. Moreover, it is expected that the price of the offset credit will be lower than the price of the permit. In terms of transaction costs this must be kept low, while also aiming to keep uncertainty to a minimum. Inconsistencies should be avoided and parties should have easy access to information (about a decrease in the cap for example). Property Rights to the Permits and Offset Credits

Carbon Sinks: As discussed in Section 4.2.6 ASC sinks will provide C sequestration services which will generate offset credits and will be able to be negotiated with sources in need to decrease their GHG emissions.

8. CONCLUSIONS

This thesis has shown that agricultural soil carbon sinks are a feasible and attractive option to provide emissions offsets as part of a DCET scheme. First soil carbon sinks were shown relevant in the context of a country's compliance with the Kyoto Protocol. Second, examples of emissions trading developments from Canada, the European Union and the U.S. were discussed.

It was found that the Canadian and the E.U. scheme differ in terms of the inclusion of ASC sinks given the different land management practices across regions. In Canada, although it is a geographically large, there is a degree of harmonization in terms of agricultural practices used across provinces and this may facilitate the implementation of a system to account for emissions reductions through C sequestered in agricultural soils. On the other hand, the European Union faces a myriad of land management practices given the cultural, economic and physical differences across regions that may hinder the development of a system to effectively manage ASC sinks which would provide emissions offset credits. As for the U.S. based Chicago Climate Exchange it was deemed an interesting example to illustrate the attractiveness of ASC sinks and offset credits. Although the U.S. has not ratified (and shows no interest in doing so) the CCX is already trading offset credits generated in american agricultural soils working in conjunction with the Iowa Farm Bureau. The CCX works on an open-market basis whereas Canada is considering implementing an Offset System where the government will serve as the buyer of offset credits and ultimate provider of these to emissions sources.

After the exploration of these developments it was noted that for the protocol's first commitment period (2008-2012) agricultural soil C sequestration will not be an option to generate offset credits given the uncertainty involved in managing C sequestered in soils, which may revert back into the environment given its nonpermanence and reversibility conditions. On the other hand the economic principles that lie behind an emissions permit trading scheme were developed. These indicate that the major advantage of a system of emissions permits is that both overall emissions control costs and individual net costs of compliance are lower than if each emitter undertook emissions control independently (Edmonds, Scott, Roop, McCraken, 1999).

Moreover, the peculiarities of ASC sinks were discussed. Among these it was noted that some land management practices can sequester more soil C than others, such is the case of no-tillage. Thus promoting no-tillage is an alternative way to create ASC sinks and provide carbon sequestration services. It was also noted that farmers will decide to adopt these practices and provide C sequestration services based on their farm opportunity cost (the cost of changing practices). The farmer's decision will also depend on the payment he will receive for changing practices (which would be the price per tonne of sequestered C) more specifically those returns relative to the costs to the farmer of changing practices. Once the farmer decided to participate in an emissions trading scheme as a seller of agricultural ASC sequestration services, the issue arises as to how to set the conditions for the farmer's involvement.

Departing from the fact that emissions credits are permanent (permanent removal of GHGs into the atmosphere) and offset credits temporal (ASC sequestration projects sequester C for a finite period) it was assumed that the market will determine the value of a permanent credit (the asset value). This value would provide a base price from which the market could determine the annual rental values for emissions credits. That is, an offset credit would be valued based on the annual return of an emissions credit. An offset credit was described as an imperfect substitute of an emissions credit to the extent that it presents higher transactions costs (due to the nonpermanence feature of ASC sink projects). How would an offset credit and emissions credit exist in a market? A rental contract approach was presented as an option to address both the temporal nature and reversibility of ASC and the administrative and legal basis to support farmers' involvement as sellers of C sequestration services. The rental contract approach offers the possibility to emissions sources to purchase soil C sequestration services from farmers over a specified period of time. The rental contract would work as a direct debit/credit system, when GHG emissions are released there is a debit and when these are sequestered there is a credit.

After this I turned to the Supply Management system in Canada in search for institutional design lessons for the proposed DCET scheme as in a way quotas and tradable permits are very similar economic instruments. Relevant institutional design topics learned from supply management economic efficiency, initial allocation and transferability, administrative board, and system issues. Moreover, using monthly data for four provinces and the differences in the prices of unused and used MSQ months, the rental value of industrial milk quotas was estimated. The ratio of this rental value to the quota purchase price measured the rate of discount used to value the quota (the rental rate). These two variables were regressed and supported the notion that market for quota rentals is rational. Prices reflected costs and returns. Policy risk was shown to affect the rental rate, and deadlines or "commitment periods" matter for the rental value and rental rate. Therefore permanent emissions credit and offset credits rental markets are expected to behave accordingly. These lessons can guide the trading rules for offset credits under the Kyoto Protocol as in this legal instrument there is the risk of a policy change and there are commitment periods.

Finally, as the main result of this thesis, defined parameters to support the guidelines for the design of a DCET scheme that accommodates emissions offsets from ASC sinks, and the ideal functioning of this system were proposed. The parameters addressed were economic efficiency, initial allocation, transferability, system issues, administrative board, property rights and general design criteria. The proposed functioning of this system differs from that offered under the Canadian DCET scheme in the way that the liability of certified sequestration projects under the Canadian DCET scheme would be assumed and guaranteed by the government, not by a broker/company that would best perform this activity. This also implies that the government would be responsible for guaranteeing the offset sequestration permanency, and overall it is foreseen that a system like this might be too costly in terms of transaction costs, such as those involved in administration, monitoring and verification. The rental contract approach leaves the door open to reach efficiency by allowing the best suited companies and farmers to participate in the C market and the trading of offset credits.

In conclusion agricultural soil C sinks can be readily included in a DCET scheme while the rental contract approach useful tool in scheme. The design process was guided with lessons from the Supply Management system which empirically shows that Emissions credits rental markets are expected to make good economic sense. Putting all these elements together it can be concluded that there is an important role for agriculture in the fight against global warming!

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APPENDICES

APPENDIX I. Definitions of Land Management Practices under the Kyoto Protocol

The following is a summary by Bettelheim & d'Origny (2002) of the definitions of Land Management Practices of the KP under Articles 2, 3.3 and 3.4.

(a) 'Afforestation' is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.

(b) 'Cropland management' is the system of practices on land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production.

(c) 'Deforestation' is the direct human-induced conversion of forested land to nonforested land.

(d) 'Forest' is a minimum area of land of 0.05-1.0 ha with tree-crown cover (or equivalent stocking level) of more than 10-30% with trees with the potential to reach a minimum height of 2-5 m at maturity in situ. A forest may consist of either closed-forest formations, where trees of various stories and undergrowth cover a high proportion of the ground, or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30% or tree height of 2-5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention, such as harvesting or natural causes, but which are expected to revert to forest. An alternative definition of forest is "vegetation type dominated by trees. Many definitions of the term forest are in use throughout the world, reflecting wide differences in bio-geophysical conditions, social structure, and economics.

(e) 'Forest management' is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner.

(f) 'Grazing land management' is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced.

(g) 'Reforestation' is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989.

(h) 'Revegetation' is a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 ha and does not meet the definitions of afforestation and reforestation contained here.

APPENDIX II. Agricultural Practices that Sequester Carbon and/or Reduce Emissions of Other Greenhouse Gases

Appendix II. **Agricultural Practices that sequester C**

Key Agricultural Practices	**Typical definition and some examples**	**Effect on greenhouse gases**
Conservation or riparian buffers	Grasses or trees planted along streams and croplands to prevent soil erosion and nutrient runoff into waterways.	Increases carbon storage through sequestration.
Conservation tillage on croplands	Typically defined as any tillage and planting system in which 30% or more of the crop residue remains on the soil after planting. This disturbs the soil less, and therefore allows soil carbon to accumulate. There are different kinds of conservation tillage systems, including no till, ridge till, minimum till and mulch till.	Increases carbon storage through enhanced soil sequestration, may reduce energy-related CO_2 emissions from farm equipment, and could affect N_2O positively or negatively.
Grazing land management	Modification to grazing practices that produce beef and dairy products that lead to net greenhouse gas reductions (e.g., rotational grazing).	Increases carbon storage through enhanced soil sequestration and may affect emissions of CH_4 and N_2O.
Biofuel substitution	Displacement of fossil fuels with biomass (e.g., agricultural and forestry wastes, or crops and trees grown for biomass purposes) in energy production, or in the production of energy-intensive products like steel.	Substitutes carbon for fossil fuel and energy-intensive products. Burning and growing of biomass can also affect soil N_2O emissions.

Source: U.S. EPAa (2004) http://www.epa.gov/sequestration/ag.html

Annex I countries under the UNFCCC include 36 industrialised countries plus some economies in transition. These had non-binding obligations to reduce their GHG emissions to 1990 levels by the year 2000. This is a list of the Annex I countries:

Annex I countries	
Australia	Japan
Austria	Latvia
Belarus	Lithuania
Belgium	Luxembourg
Bulgaria	Netherlands
Canada	New Zealand
Czech Republic	Norway
Denmark	Poland
European Union	Portugal
Estonia	Romania
Finland	Russian Federation
France	Slovakia
Germany	Spain
Greece	Sweden
Hungary	Switzerland
Iceland	Turkey
Ireland	Ukraine
Italy	United Kingdom of Great Britain and Northern Ireland

Annex B of the Kyoto Protocol includes a list of 39 countries, which have emission reduction obligations to reach 1990 emissions levels by the first commitment period 2008-2012. Annex B is composed of the following nations:

Annex B countries	
Australia	Liechtenstein
Austria	Lithuania
Belgium	Luxembourg
Bulgaria	Monaco
Canada	Netherlands
Croatia	New Zealand
Czech Republic	Norway
Denmark	Poland
European Union	Portugal
Estonia	Romania
Finland	Russian Federation
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Iceland	Switzerland
Ireland	Ukraine
Italy	United Kingdom of Great Britain and Northern Ireland,
Japan	United States of America
Latvia	

Commonly Annex I of the UNFCCC and Annex B of the Kyoto Protocol are referred to as being the same entity. However, it is the Annex I countries which can invest in Joint Implementation (JI)/ Clean Development mechanism projects as well as host JI projects; and non-Annex I countries which can host CDM projects (CO2e.com, 2004).

APPENDIX IV. CCX soil offset credit sale contract

Farm Bureau Management Corp.
5400 University Ave
West Des Moines, Iowa 50266

Contract No._______________
Iowa

APPLICATION FOR PARTICIPATION IN CHICAGO CLIMATE EXCHANGE
SOIL CARBON POOL and
CREDIT SALE CONTRACT for EXCHANGE SOIL OFFSETS (XSOs)

Seller______________________________ Phone______________ Date_______________

Address____________________________ City/State/Zip___________________________

I, ________________________, hereby apply for registry of Exchange Soil Offsets (XSOs) with the Chicago Climate Exchange (CCX) for the years 2003-2006 on property that I own or control. I hereby agree that ______ acres shall be in continuous conservation tillage as defined in this Agreement and that _____ acres shall be in continuous grass cover that was established on or after January 1,1999. I further agree that I will abide by the rules of the CCX as they pertain to XSOs and to the conditions for Pool participation as set forth in this agreement.

Signed___________________________ Date_____________________

Purchaser agrees to buy and seller agrees to sell and deliver to purchaser free from liens and encumbrances at 5400 University Ave, West Des Moines, Iowa, the rights to the Exchange Soil Offsets (XSOs) created during the years 2003 through 2006 through the application of

Conservation Tillage to _________ acres and/or Permanent Grass Cover to __________ acres located at:

Please complete and attach the Exchange Soil Offset Enrollment Worksheet

XSOs accrue at the rate of 0.5 XSO per acre per year for eligible minimum till/No-till.
XSOs accrue at the rate of 0.75 XSO per acre per year for permanent grass cover.
20% of the accrued XSOs shall be held in reserve by the Purchaser until December 31, 2006.

Seller warrants that the XSOs covered by this contract comply with all rules of the Chicago Climate Exchange. In particular Seller warrants that the land from which the XSOs covered by this contract arise shall be in continuous conservation tillage or permanent grass cover, as applicable, during the period

APPENDIX V. Description of different pollutant trading markets

The following is an excerpt from the International Emissions Trading Association webpage (IETA, 2005), which effectively describes the differences between several pollutant trading markets. The diversity of trading markets is primarily a consequence of the products traded and the scope of the market.

- Bubbles allow an entity with multiple emissions sources to combine their total emissions targets from these multiple sources under one accounting entity. This creates flexibility to apply pollution control technologies to whichever source under the bubble has the most cost effective pollution control options, while ensuring the total amount of emissions under the bubble meets the overall environmental restrictions.

- Offsets or Credit-Based Emission Reduction Trading represent the next iteration of emissions trading. These systems are project-based, often incorporating non-capped industries and entities. This system allows entities that wish to increase their emissions to obtain offsetting reductions from entities that are not required to reduce their emissions. Offsets are created when an emitting company makes voluntary, permanent emission reductions that are legally recognized by a regulator as emission reduction Credits or Offsets. Those Offsets are sold to new, or expanding emission sources to 'offset' the new emissions. Regulators approve each trade; however, regulators usually require a percentage of the Offsets be retired as a dividend to the environment.

- Cap and Trade Programs are more evolved forms of emissions trading. A regulatory authority establishes an aggregate cap on the emissions of a pollutant that is a firm and permanent limit for a group of emitters. The allowed cap has historically been a fraction of the historic emissions from those sources. For example, the U.S. Acid Rain Program instituted a 50% reduction from 1980 levels of SO_2 emissions from utilities, and the Ozone Transport Commission NO_x Program imposed a 65% reduction from 1990 levels and is scheduled to achieve an 85% reduction after the next phase. Emission Allowances are unit of trade created to account for the total emissions in the system (in the case of the U.S. Acid Rain Program, 1 emission allowance equals the right to emit 1 ton of sulphur dioxide). Trading occurs when an entity with excess allowances, liberated through actions or improvements made, sells them to an entity requiring allowances.

There are also two additional concepts involved with emissions trading that can be combined with the above systems.

- Baseline Emission Reduction Trading systems are project-based, often incorporating non-capped industries and entities. This type of system allows an entity to voluntarily reduce emissions below emissions that would otherwise occur under business as usual. The accreditation system is based upon the delta between two emission forecasts: with and without the proposed project. The Clean Development Mechanism (CDM) is such a mechanism.

- Rate-based Emissions Trading focuses on the emission per unit of output rather than absolute emissions. This system is intended to promote increased efficiency without limiting growth of the underlying business. Within such a system entities that improve their efficiency beyond the target levels can trade the excess improvement with other companies. Corporate Average Fleet Efficiency (or CAFE) standards in the U.S. allow auto manufactures to make changes within their own fleet of vehicles to ensure an overall average improvement in gas mileage per vehicle sold.