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Greenhouse-gas-trading markets

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This paper summarizes the extension of new market mechanisms for environmental services, explains of the importance of generating price information indicative of the cost of mitigating greenhouse gases (GHGs) and presents the rationale and objectives for pilot GHG-trading markets. It also describes the steps being taken to define and launch pilot carbon markets in North America and Europe and reviews the key issues related to incorporating carbon sequestration into an emissions-trading market.

There is an emerging consensus to employ market mechanisms to help address the threat of human-induced climate changes. Carbon-trading markets are now in development around the world. A UK market is set to launch in 2002, and the European Commission has called for a 2005 launch of an European Union (EU)-wide market, and a voluntary carbon market is now in formation in North America.

These markets represent an initial step in resolving a fundamental problem in defining and implementing appropriate policy actions to address climate change. Policymakers currently suffer from two major information gaps: the economic value of potential damages arising from climate changes are highly uncertain, and there is a lack of reliable information on the cost of mitigating GHGs. These twin gaps significantly reduce the quality of the climate policy debate.

The Chicago Climate Exchange, for which the authors serve as lead designers, is intended to provide an organized carbon-trading market involving energy, industry and carbon sequestration in forests and farms. Trading among these diverse sectors will provide price discovery that will help clarify the cost of combating climate change when a wide range of mitigation options is employed. By closing the information gap on mitigation costs, society and policymakers will be far better prepared to identify and implement optimal policies for managing the risks associated with climate change.

Establishment of practical experience in providing tradeable credits for carbon-absorbing land-use practices, especially reforestation and conservation management of agricultural soils, will also help demonstrate the viability of a new tool for financing activities that improve water quality, support biodiversity and constitute important elements of long-term sustainability in land-use management.

Keywords: climate change; emissions trading; carbon-trading market; carbon sequestration; offset projects

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1. Introduction

In this paper you will find the following.

- (i) A summary of the historical development patterns observed in newly organized markets, and an assessment of the status of the emerging greenhouse-gas (GHG) markets in the context of the inventive process.
- (ii) Discussion of the logical extension of new market mechanisms for environmental services.
- (iii) Presentation of the rationale and objectives for pilot GHG-trading markets.
- (iv) An explanation of the importance of generating price information indicative of the cost of mitigating GHGs.
- (v) A summary of the steps being taken to define and launch pilot carbon markets in North America and Europe.
- (vi) A review of key issues related to incorporating environmental services associated with carbon sequestration into a carbon-trading market.

The history of new markets offers many examples where societal demand to deploy capital to address particular objectives helps stimulate the formation of organized markets. Increasing societal demand for cost-effective methods for improving environmental quality has ushered in a variety of successful market-based environmental-protection programmes. There is an emerging consensus to employ market mechanisms to help address the threat of human-induced climate changes.

Carbon-trading markets are now in development around the world. A UK market is set to launch in 2002, and the European Commission has called for a 2005 launch of an EU-wide market. The Chicago Climate Exchange (CCX) is a voluntary carbon market now in formation in North America. These markets represent an initial step in resolving a fundamental problem faced by those seeking to define and implement appropriate policy actions to address climate change. Policymakers currently suffer from two major information gaps. The first is that the scale of potential damages arising from climate changes is highly uncertain. The other important gap is a lack of understanding of the monetary costs associated with action to mitigate GHGs. These twin gaps significantly reduce the quality of the climate policy debate.

The CCX, for which the authors serve as lead designers, is intended to provide an organized carbon-trading market involving energy, industry and carbon sequestration in forests and farms. Trading among these diverse sectors will provide price discovery that helps clarify the cost of managing GHG concentrations and combating climate change when a wide range of mitigation options is employed. By closing the information gap on mitigation costs, society and policymakers will be far better prepared to identify and implement optimal policies for managing the risks associated with climate change.

Establishment of practical experience in providing tradeable credits for carbon-absorbing land-use practices, especially reforestation and conservation management of agricultural soils, will also help demonstrate the viability of a new tool for financing activities that improve water quality, support biodiversity and constitute important elements of long-term sustainability in land-use management.

2. Development patterns observed in newly organized markets

The historic pattern of successful implementation of various organized markets, including environmental markets, offers insights as to the feasible paths for development of markets established for the purpose of reducing GHG emissions (Sandor 1992, 1999). As discussed in Sandor *et al.* (2002), the first step is the emergence of demand for capital to flow to address a specific objective. The past decade has seen a crystallization of the sort of structural change that demands that resources be dedicated to protection against the risk of climate change. The international effort to formalize the demand for GHG mitigation through the United Nations Framework Convention on Climate Change (UNFCCC) has seen a multitude of parallel efforts through national and local policy actions, as well as in the private sector. Standards that can provide the foundation for widespread use of emissions trading as a tool for cost-effectively cutting GHGs are now emerging in both the public and private sectors. The establishment of legal trading instruments is underway, spot markets are being developed in numerous locations and derivative markets are already being considered.

From a higher-level perspective, if we apply Joseph Schumpeter's summary of the three phases of inventive activity—*invention, innovation and replication* into commercialized forms—then one can say that development of the GHG market is an example of the commercialization or extension stage (Schumpeter 1942). The early efforts during the 1970s to exploit cost efficiencies and gains from trade gave industry limited flexibility in the form of multi-plant 'bubbles' or emission-netting schemes. Following these attempts to 'invent' practical emissions-trading systems, innovation during the 1980s took the form of better-defined and more-easily-traded emission rights. These improvements were employed in the US programmes for reducing lead content in motor fuel, and in the highly successful acid-rain-reduction programme that introduced commodity-like trading in SO₂ allowances in the 1990s (Sandor & Walsh 2000). Having built a basis of experience, the hypothesis that the time-frame for designing and launching GHG markets can be accelerated will now be tested.

In any event, the challenges associated with incorporating carbon sequestration into the GHG markets makes it likely that these markets will go through several iterations over the next two decades as experience is gained, as measurement technology improves and as market participation and value grows. The initial efforts to develop GHG-trading markets may produce successes, partial successes and failures. But all the efforts can be expected to yield lessons that can help guide the formation of successful later-generation markets.

3. Extension of new market mechanisms for environmental services

The international community has codified a climate-protection strategy that allows for a broad range of market-based tools for managing and reducing GHGs. As with all emissions-trading systems, the ultimate goal is to lower overall mitigation cost by exploiting gains from trade, using price signals to guide resources to their most efficient use and stimulating innovation.

The incorporation of a variety of market-based tools for managing GHG emissions in part reflects the success in using these tools for managing other environmental problems. Indeed, it is unlikely that the climate convention would have contained

its various emissions-trading mechanisms had there not been successful large-scale demonstration of the concept.

The agreement that has emerged from the UNFCCC and its Kyoto Protocol has also formally recognized the major influence of land-use management on GHG concentrations. This represents a critically important extension of the emissions-trading concept that potentially has profound benefits for ecosystems and biodiversity. This new dimension of emissions trading holds promise to provide an additional tool for financing land-use practices and conservation investment on a significant scale. If the opportunity can be successfully harnessed, society can simultaneously reduce the threat of climate change while enhancing natural landscapes and realizing the co-benefits of habitat protection, improved water quality and increased aesthetic values. Importantly, introduction of new tools for financing sustainable land use offers the potential to increase the viability of local economies and indigenous societies that are dependent on healthy forest systems (Walsh 1999).

The Kyoto Protocol provides an initial approach for including the role of biomass and soil carbon in its GHG limits and market mechanisms. Article 3.3 of the Kyoto Protocol calls for counting the net contribution of human-induced afforestation, reforestation and deforestation since 1990 in the 38 industrialized countries for which the specified emission limits are intended to apply. Article 3.4 directed that the climate conference to determine which GHG removals by sinks in the agricultural soils and the land-use change and forestry categories should be incorporated into the Protocol. The completion of the Marrakech meetings of the climate convention provided guidance on these activities, the inclusion of which was a major concern for several countries such as Canada and Australia. Importantly, the Marrakech Accords also provide for recognition and crediting of afforestation and reforestation projects in developing countries via the Protocol's Clean Development Mechanism.

The objectives of the climate and biological diversity conventions are deeply intertwined. Habitat alteration, which some view to be associated with ongoing changes in the Earth's climate, is the principle cause of species loss and endangerment. At the same time, the market mechanisms established in the UNFCCC and Kyoto process introduce a new source of financial support for enhancement and protection of biological habitat. The challenge now is to implement practical market mechanisms that provide demonstration benefits while testing methods for handling the technical challenges that are inherent in all environmental protection programmes.

The Kyoto Protocol, as well as related initiatives being undertaken by national and local governments and the private and non-governmental sectors, provides the opportunity to incorporate the carbon-sequestration services realized through enhancement carbon 'sinks'. The various emerging markets for trading in carbon credits can be harnessed to enhance habitats by providing a new source of financing for reforestation and agricultural-management practices that can contribute to improved ecosystems.

4. Rationale and objectives for pilot GHG-trading markets

The argument that emissions-trading markets will help lower the cost of mitigating GHGs rests on the assumption that such markets can be established and integrated internationally, that their transaction costs can be kept low and that they can ultimately succeed in guiding global mitigation resources to the least-cost options. Con-

sidering the limited experience with emissions trading worldwide, the introduction of early pilot trading programmes represents a critically important step in the process of building, refining, spreading and integrating these markets. It is widely observed that the best way to advance the process is to promptly begin trading, even if on a limited scale, so that institutions and skills can be built on the basis of real-world experience. Pilot GHG markets can offer a means to do just that.

The formation of a pilot market requires resolution of a wide range of design questions and implementation challenges. These include: defining emissions, sources and offset projects to be included; monitoring and verification protocols; establishing registries and reporting procedures; enrolling participants; determining baselines; allotting allowances and enrolling offset projects; and assuring effective true-up of emissions and allowance and offset holdings. Each of the steps presents a number of challenges due to political, technical and institutional constraints, and many of the required steps introduce the need to create new approaches to solve the issue at hand. At the same time, practices used in other commodity and environmental markets do offer approaches that can be applied to formation of a GHG market.

As the myriad practical issues are resolved, the initial market architecture that emerges will represent a foundation upon which the market refinement and expansion process can be built. While the industrialized countries that start early can probably realize successful iteration within a decade, the spread of effective GHG trading to a large number of countries is likely to take significantly longer. The inevitability of the build, test and refine cycle makes it critically important to start soon. In order to begin realizing the benefits that a GHG market can produce for ecosystems in developing countries, it is important to include sequestration activities in the emerging markets as soon as possible.

To summarize, the rationale for pilot GHG trading is to

- (i) test methods and technologies;
- (ii) build expertise among emission sources and offset projects;
- (iii) initiate the process of managing GHG limitations as a conventional business practice;
- (iv) begin the process of harnessing GHG markets for the direct benefit of ecosystems; and
- (v) generate price information indicative of the cost of GHG mitigation.

This final point is now discussed further.

5. Significance of price information indicative of the cost of mitigating GHGs

The long-running debate over the appropriate degree of GHG mitigation to be pursued will continue as individual countries consider signing on to near-term action, and as the international community prepares to consider Kyoto's second-round mitigation goals. However, this debate suffers from two major information gaps. The first is a lack of consensus regarding the damages that could occur if action to reduce GHG

emissions is not taken. Stated another way, the benefits of taking mitigation actions are uncertain.

The second information gap is a lack of understanding of the monetary costs associated with mitigating GHGs. The implicit cost–benefit analysis underlying the climate debate dictates that for any particular level of benefits accruing from action to mitigate climate change, a high cost of mitigation will lead policymakers to take less action. If mitigation costs were known to be low, policymakers would be likely to support stronger action.

At this time, however, society does not have reliable data on the costs involved in pursuing climate-mitigation actions. Establishment of emissions-trading systems thus becomes imperative, since policy decisions are now being made. In addition, while many assume that enhancement of terrestrial carbon sinks offers one of the least-expensive GHG-mitigation options, the institutional capacity to properly include this option is not currently in place.

Generation of price information indicative of mitigation costs should be considered a primary objective of pilot GHG-trading programmes. However, as discussed below, the pilot markets being developed in the UK and the European Union (EU) do not include north–south international trade or carbon-sequestration activities. Because actions to increase carbon sequestered in soils, forests and other biomass is widely considered to be one of the least-cost mitigation options, this omission may cause the price information to be generated in the UK and EU markets to misrepresent the true cost of mitigation if all GHG-mitigation options were to be exploited. This omission is all the more perplexing given the explicit recognition of sequestration activities in the Kyoto Protocol.

6. Pilot carbon markets under development in North America and Europe

Pilot GHG-trading systems are emerging in North America and Europe. These programmes are intended to begin building institutions and skills needed to form broader markets in the coming years. It is important to note that, while the emissions-reduction commitments under the Kyoto Protocol (which the EU countries appear ready to accept) do not become binding until 2008 and later, the UK and EU pilot markets are planned for launch well in advance of the Kyoto time-frame. The early start will help to reveal strengths and weaknesses of the initial approaches taken, thus generating benefits from the ‘learning by doing’ approach. Regrettably, the long-standing hesitation of European countries to embrace the role of carbon sequestration as an important component of GHG management appears to have contributed to the omission of land use and sequestration from the first-generation markets in Europe and the UK.

At the national governmental level, the UK has recently launched an emissions-trading system for GHGs developed by the government and a consortium of businesses known as the Emissions Trading Group (DEFRA 2001). The British government has indicated that it will attempt to merge this initiative into the pilot EU programme with as little friction as possible. The programme is a voluntary pilot open to all sectors except transport and power generation. It covers all six categories of GHGs, employs allowance allocations and offers government-provided financial incentives to participate. At this time, the UK programme does not allow crediting

Table 1. *Proposed salient features: CCX*

market design	cap-and-trade 'allowances' and project-based offsets
geographic coverage	emissions sources in the US starting in 2003, with expansion to sources in Canada and Mexico; offsets from projects in Brazil
emissions-reduction schedule	proposed cuts to 2% below baseline in 2003, further 1% cuts annually through 2006; baseline is proposed to be 1998–2000
offset projects	afforestation and reforestation, agricultural soil carbon and emission cuts, landfill methane destruction, renewable energy systems
trading system and auctions	web-based electronic trading platform, periodic auctions to generate price information and liquidity

for carbon-sequestration projects, but the issue is subject to review in the future. The programme was activated when emission sources signalled their intent to take on emissions-reduction commitments by 'bidding in' their proposed reduction quantities into an auction mechanism conducted in the first quarter of 2002.

The European Commission released a proposal at the end of October 2001 to establish an emissions-trading programme to start in 2005 (CEC 2001). Noting that CO₂ makes up 80% of the total GHG footprint in the EU, and citing its relative ease of monitoring, the proposal calls for including CO₂ only in the market's initial phase. The plan targets large facilities in the energy, metals, mineral-processing and forest-products sectors. The proposal is silent on the issue of carbon sequestration.

Efforts are also under way in the Netherlands, where the government plans to form a CO₂-trading system by 2004–2005. In Germany and Japan, working groups made up of members of the public and private sectors are discussing steps to establish GHG-emissions-trading markets. Denmark launched the first national domestic GHG-emissions-trading market, but it was limited solely to the power sector. It is notable that the German Green Party, which is not generally known to support markets and industry, proposed the establishment of an early national GHG-trading programme.

Efforts in North America to form organized early pilot markets for GHG trading appear at this time to be limited to the preparations being undertaken by the CCX. The Joyce Foundation, through a grant to Northwestern University, has provided the funding to prepare a feasibility study for the exchange and to implement the design phase of the project under the direction of our Chicago-based company, Environmental Financial Products LLC. Market launch is targeted for late 2002.

The CCX is preparing a hybrid market architecture that will blend a cap-and-trade allowance system with project-based offsets, including sequestration projects. The exchange will issue annual allowances equal to each member-company's target level. A registry will be established with accounts containing each participant's allowance and offset holdings. Offsets from eligible projects, such as biomass sequestration in North America and energy or sequestration projects in Brazil, will also be registered and can be used for compliance. Companies will monitor and report actual emissions in a linked database. Just as in the SO₂ programme, subsequent to the end of each year, allowances plus offsets equal to actual emissions must be

relinquished. Participating companies that have emitted more CO₂-equivalent emissions than the allowances they hold may purchase offsets or allowances to achieve compliance. Participants having excess allowances or offsets may sell or bank them. Table 1 presents the salient features of the CCX.

There are currently 46 entities participating in the formulation of rules for the CCX (see table 2). They have expressed their intent to participate further by taking emissions-limitation commitments and trading if the final rules are compatible with their strategic objectives. The participating entities include the electric-power, oil and gas, forest-products, manufacturing and landfill-management industries, as well as two large municipalities. They also include offset providers from wind, solar and hydroelectric power companies, farmers' cooperatives and environmental and conservation organizations specializing in carbon-sequestration projects.

CCX participants include the two largest forest-products companies in the world, the largest electricity generator in the US and several leading-edge land-stewardship groups. Total annual emissions from the participating industrial entities are *ca.* 700 million tonnes CO₂ equivalent, nearly equal to those of Germany.

It is important to note that the inclusion of carbon-sequestration activities undertaken in the industrial-forest sector, in the agricultural sector and through projects undertaken by conservation groups offers the prospect of generating a more robust price signal compared with a market that excludes sequestration. Provisions to assure that sequestration offsets do not flood the market will be examined so that prices reflect a balance of industrial emissions reductions and sequestration. As discussed below, inclusion of a variety of sequestration activities introduces an array of technical and institutional challenges. Put another way, this diverse range of land-use activities presents a perfect opportunity to begin building methods and capacity to effectively include sequestration in GHG markets worldwide.

7. Key issues related to incorporating carbon sequestration into a GHG-trading market

By incorporating carbon sequestration in managed forests, as well as sequestration by specifically targeted project-based sequestration offsets from the outset, the CCX programme provides an early opportunity to begin building a broad portfolio of mitigation activities, and to learn through practice. This will help CCX participants and others learn more about the practical mechanics of implementing, quantifying, registering and trading offsets from land-use activities in the context of an organized carbon market.

Despite the massive amount of discussion and debate surrounding the inclusion of sequestration in GHG-mitigation efforts, there is relatively limited practical experience with sequestration crediting. In order to build experience with sequestration crediting, the CCX will include the following categories of carbon-sequestration activities in its first phase.

- (i) Afforestation and reforestation and other revegetation projects.
- (ii) Soil sequestration through on-farm conservation practices.
- (iii) Net changes in carbon-storage balances realized by forest-product companies.

Table 2. *Entities participating in the CCX design phase*

energy	Alliant Energy American Electric Power BP Cinergy CMS Generation DTE Exelon FirstEnergy Manitoba Hydro Midwest Generation NiSource Ontario Power Generation PG&E National Energy Group Pinnacle West Corporation (APS) Suncor Energy TXU Energy Trading Wisconsin Energy
industry	Baxter Cemex DuPont Ford Motor Company Grupo IMSA de Mexico Interface ST Microelectronics Waste Management Inc.
offset providers	Agriliance Cataguazes-Leopoldina Conservacion Mexico Ducks Unlimited Growmark Iowa Farm Bureau Federation National Council of Farmer Cooperatives Navitas Energy Nuon Ormat Pronatura Noreste The Nature Conservancy
service providers	American Agrisurance Det Norsk Veritas Edelman PR IT Group SCS Engineers Swiss Re Carr Futures/Crédit Agricole Winrock International
forest-products companies	International Paper Temple-Inland Mead Corp. Stora Enso
municipalities	City of Chicago Mexico City

Early inclusion of these activities will help address questions that have to date been largely theoretical, such as the following.

- (i) What are practical and cost-effective methods for quantifying carbon sequestration?
- (ii) How can multiple projects be aggregated to exploit economies of scale in trading?
- (iii) What environmental co-benefits are realized?
- (iv) What efforts are needed to assure sequestration effectiveness in the aggregate?

In order to improve the chances that answers to the above questions can be generated by the CCX pilot, the market design focuses on finding an initial balance between assuring confidence in the environmental effectiveness of sequestration projects and keeping transaction costs low enough to foster participation. The market design endeavours to establish standardized protocols whenever possible. In order to be confident that a standardized procedure does not overstate the true environmental effectiveness of a sequestration project, simplifications introduced for the purpose of lowering transaction costs will employ discounted sequestration values. For example, due to statistical factors and other considerations, it is extremely expensive to quantify increases in carbon sequestration in agricultural soils within reasonably narrow confidence bands. This expense grows for when the carbon increments occur over shorter time periods. To avoid this prohibitive cost, default values and model-based estimates of sequestration are being developed based on expert input. By adopting a specified quantitative relationship that links management practices to annual sequestration quantities, the CCX will mandate only that the management practice specified by contract is, in fact, undertaken.

In the course of developing protocols for the CCX, a number of important conceptual and technical questions have arisen. Among the more interesting ones are the following.

- (i) Must forest-carbon quantification protocols be standardized across participants? How can this be done?
- (ii) How are afforestation and reforestation projects defined? Can avoided deforestation be defined, consistently quantified and included in a pilot market?
- (iii) What project-verification methods should be employed?
- (iv) How can increased carbon stocks in agricultural soils be quantified at acceptable cost?
- (v) How can the market architecture help assure long-term carbon storage?
- (vi) How can multiple small projects be aggregated so that per-tonne transaction costs decline?
- (vii) How should long-term storage of carbon in wood products be reflected in the carbon accounts of forest-product companies?

- (viii) What methods for pooling and insuring sequestration projects offer cost-effective means for assuring that sequestration projects achieve and maintain progress in storing increased amounts of carbon?

The answers to these questions are being developed with industry input, expert advice of academics and forest and soil consultants, through incorporation of research findings reported in the literature, and by reference to international standards. While compromises between accuracy and cost must be made, the philosophy of using conservative discounted values whenever lower-cost quantification methods are used is expected to prove effective. The pilot will not realize the objective of having robust participation and a variety of sequestration activities unless a number of steps are taken to reduce transaction costs.

Inclusion of a variety of carbon-sequestration activities in the CCX is considered a first step in a series of efforts needed to help harness the emerging global market in GHG mitigation for the benefit of ecosystem enhancement and conservation. The ultimate success of this endeavour, which might take 10–20 years to realize, may represent a major new source of funding for land-use management practices that produce simultaneous benefits for local communities, water quality and wildlife.

8. Conclusions

The UN climate convention emerged from the 1992 'Earth Summit' at Rio de Janeiro, which also formally introduced the Convention on Biological Diversity. Given the potential for carbon sequestration and credit trading to significantly enhance land conservation and stewardship, it can be argued that the efforts to pursue the goals of the climate convention can also represent the most important set of actions that advance the goals of the Biodiversity Convention.

The UN process has introduced a framework for conducting international trade in GHG reductions and sequestration. However, implementation is largely left to national governments and others who can make these mechanisms operational around the world. The introduction of pilot GHG markets that include carbon sequestration is a first step in a sequence of efforts that will be needed to harness the carbon markets for the benefit of terrestrial ecosystems. The early pilot markets must be viewed as a test phase from which lessons can be drawn and necessary improvement identified. As practical experience is gained, and as technologies such as remote sensing mature, the ability to broaden the reach of benefits to ecosystems worldwide will grow.

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