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Mitigating Climate Change by Planting Trees: The Transaction Costs Trap

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Mitigating Climate Change by Planting Trees:

The Transaction Costs Trap

by

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Abstract

Land-use change and forestry projects are considered to be a low-cost option for addressing climate change mitigation. In Canada, investments in afforestation are targeted to sequester enough carbon to meet one-fifth of its international obligations, and at lower cost than emissions reduction. In this paper, we examine economic aspects of the institutions and incentives needed to encourage landowners in Canada to adopt tree planting on a large enough scale to matter. Using data from a survey of landowners, we find that the transaction costs of getting landowners to convert their land from agriculture to plantation forests may be a significant obstacle, increasing the costs of afforestation projects beyond what conventional economic analysis suggests.

Key words: afforestation; carbon trading; transaction costs and the new institutional economics

Mitigating Climate Change by Planting Trees: The Transaction Costs Trap

1. Background

Land-use change and forestry (LUCF) projects that result in greater carbon storage in terrestrial ecosystems are widely seen as a low-cost alternative to CO_2-emissions reduction for addressing climate change (Obersteiner et al. 2001; Sohngen and Alig 2000; Chomitz 2000; Frumhoff et al. 1998). Under Kyoto's Clean Development Mechanism (CDM), industrialized countries could purchase certified carbon offsets from developing countries by sponsoring projects that reduce CO_2 emissions below business-as-usual levels in those countries. Likewise, emission reduction units can be produced through Joint Implementation (JI) projects in countries whose economies are in transition. Projects that prevent or delay deforestation and land-use change, or result in the establishment of plantation forests, are eligible under the CDM and JI. Industrialized countries can also pursue domestic LUCF projects, which favors countries with a large land base and low population density. Canada, for example, envisions meeting 22% of its Kyoto commitment through terrestrial sinks (Canadian Pulp & Paper Assoc. 1999).

In principle, a country should get credit only for sequestration above and beyond what occurs in the absence of carbon-uptake incentives, a condition known as "additionality" (Chomitz 2000). Thus, for example, carbon (C) sequestered as a result of incremental forest management activities (e.g., juvenile spacing, commercial thinning, fire control, fertilization) would be eligible for C credits, but only if the activities would not otherwise have been undertaken (say, to provide higher returns or maintain market share). Similarly, afforestation projects are additional if they provide environmental benefits (e.g., regulation of water flow and quality, wildlife habitat) not captured by the landowner and would not be undertaken in the absence of economic incentives, such as subsidy payments or an ability to sell carbon credits. The case for additionality is easier to make for tree planting on agricultural land than for enhanced management of extant forestland (Caspersen et al. 2000).

Estimated costs of LUCF options depend on where they are located, and whether they occur in developing or developed countries. Frumhoff et al. (1998) identify potential

LUCF projects in a number of developing countries, with costs ranging from negative values to about $10 per tonne C (tC). LUCF projects that result in negative costs of C uptake are generally high-yielding plantation forests that do not meet the test of additionality, because they should be undertaken even in the absence of C-offset incentives. There are other LUCF projects in developing countries that do meet the additionality test and can be pursued at costs of less than $25 per tC. Afforestation projects in industrial countries and countries in transition can be pursued at costs of $5-$136 per tC (Sohngen and Alig 2000; Henri 2001). While some energy projects that result in reductions in CO_2 emissions can be pursued at very low cost, their extent is limited in terms of global targets, and most energy projects are likely more costly to pursue than LUCF projects (Obersteiner et al. 2001; Henri 2001).

Traditional economic techniques are used to estimate the costs of carbon sequestration related to LUCF projects, but they generally assume transactions are costless. In the case of afforestation in developed countries, for example, it is assumed that land can be transferred from agriculture into forest plantations (or back to agriculture) seamlessly – that there is no resistance from farmers and no unaccounted for costs related to the mechanism used to encourage landowners to plant trees. The purpose of this paper is to argue that there are indeed transaction costs associated with the development of plantation forests that could thwart any attempts by government to implement afforestation on a large scale. To do so, we employ results from a survey of agricultural landowners in western Canada.

We begin in the next section by demonstrating that LUCF projects in Canada generally meet the test of additionality. However, the success of any program to induce landowners to change their land use will depend on how it is packaged. What role do transaction costs play, and what influences them? What incentives and institutions are needed to get landowners to adopt large-scale tree planting programs, and keep the costs of such programs to a minimum? These issues are addressed from a theoretical perspective in sections 3 and 4, where we apply ideas from the new institutional economics (NIE) to the problem of contracting to plant trees. In section 5, we employ the results of a survey of landowners in western Canada to provide insights concerning transaction costs and the design of appropriate institutions and economic incentives for creating additional terrestrial carbon sinks at least cost. Our conclusions follow.

2. Economics of Tree Planting on Agricultural Land in Canada

One can determine whether or not afforestation meets the "additionality" test by making a few simple calculations. Consider first planting native white spruce and aspen on marginal agricultural land in Canada's forest-grain belt transition zone (see van Kooten et al. 2000). The current land use is often native pasture that permits two animal unit months of grazing per ha per year, valued at \$7 each or \$14 ha^{-1} yr^{-1}. Spruce and aspen are harvested at age 80 years and yield no more than 180 m^3 ha^{-1}. Assume that, at harvest time, stumpage value is (a high) \$40 m^3. A dollar accruing 80 years in the future is worth \$0.044 today if the discount rate is about 4%. The discounted returns from planting aspen or white spruce (about \$320 ha^{-1}) approximately equal the opportunity cost of the land (about \$330 ha^{-1} over the 80 years), but are inadequate to cover initial planting costs, which range from \$500 to \$1500 ha^{-1}. Thus, for spruce and aspen, discounted net returns are negative. While there are external benefits from planting spruce and aspen (reduced soil erosion, biodiversity, carbon uptake), planting will not occur without subsidies.

Now, for the same scenario as above, assume that rapid-growing hybrid poplar is planted, that the rotation age is 15 years, so the discount factor is 0.555 for a discount rate of 4%, and that 190 m^3 ha^{-1} is available at harvest time (see van Kooten et al. 2000). Then the discounted return from harvest in 15 years (assuming a lower stumpage value of \$25 per m^3) is about \$2600 ha^{-1}. The discounted opportunity cost of land over the 15 years in \$156 ha^{-1}, but establishment costs for hybrid plantations are higher than for native species, perhaps some \$1500-\$2000 ha^{-1}. The net discounted return to hybrid poplar is thus some \$450-\$950 per ha per rotation, or \$1000-\$2100 in perpetuity.

If hybrid poplar does indeed yield higher long-run net returns than extant agricultural activities, why have landowners not adopted this land use? There are some possible reasons. First, there remains uncertainty about the costs of tree planting, yields and stumpage values. Costs and benefits will vary by geographical location, including nearness to saw mills, pulp mills or biomass burning facilities. Second, returns to current investments accrue in the distant future, so the landowner's income stream is not regular.

This could explain van Kooten's (2000) conclusion that it might take 25 to 40 years (or longer) for Canada to reach its C-uptake potential through an afforestation program. Third, landowners may perceive the financial risks of planting hybrid poplar to be too great. Fourth, by planting trees, farmers may feel that their ability to participate in current and future government agricultural programs is threatened. Finally, despite positive benefits of forests (e.g., reduced soil erosion), relative to native species the negative environmental effects of hybrid poplar plantations, such as reduced biodiversity and susceptibility to disease (Callan 1998), limit their viability as an alternative land use.

Afforestation projects in Canada appear to meet the additionality condition: To get landowners to plant trees, it will be necessary to provide subsidies or other incentives. To be effective and competitive with other methods of reducing CO_2 in the atmosphere, it will be necessary to implement the "right" policies. What are the prospects?

3. Tree Planting on Agricultural Land: Coordination Mechanisms

Neoclassical economics assumes that decision-makers are rational economizers who have perfect knowledge; markets are perfectly competitive, homogeneous goods are traded and prices embody all of the needed information; transaction costs are ignored as is market failure more generally. The new institutional economics (NIE) differs from neoclassical economics in some fundamental ways (Acheson 1994).

- The NIE takes the position that economic agents are rationally bounded, while information is costly to obtain. Agents do not have perfect information but are often opportunistic, acting in their own self-interest with guile. People are only weakly rational and weakly moral, often withholding information when it is in their interests to do so (Acheson 1994, p.8). Bounded rationality and opportunism *cause* transaction costs (CPB 1997, p.46). Yet, transactions take place even though information is incomplete or distorted. Further, people do not always have exclusive rights to what is traded (e.g., to carbon credits), which then becomes a source of uncertainty and leads to incomplete contracting.
- There are costs to using markets because of market imperfections and outright market failure.

- In many transactions (including ones that deal with provision of tree planting services) price is not the sole consideration. There exists a range of social and legal ties among people, and extra-market benefits are common.
- Finally, a key assumption of the NIE is that institutions have a strong impact on the economic system and that institutions are often the result of political processes.

Four economic coordination mechanisms are available for addressing below socially optimal tree planting in agriculture: competition, control (regulation or state ownership), cooperative exchange (contracts), and common values and norms. Cooperative exchange, and common values and norms, are intermediary between the extremes of competition and control. Competition may be more appropriate in a heterogeneous society, while common values and norms develop more easily in a homogeneous society (CPB 1997, pp.42-44). In Sweden, for example, moral suasion and education (values and norms) are used in lieu of regulation to get many small forestland owners to supply nature (greater biodiversity) despite reduced commercial timber benefits; in other jurisdiction, onerous regulations are required (see Wilson et al. 1999).

Provision of C-uptake services (carbon offsets) is not costless, but it could be made costlier by inappropriate choice of a coordination mechanism. The ability to implement a coordination mechanism (if at all) depends crucially on existing institutional arrangements, or governance structure, within the jurisdiction. It is not possible, for example, to implement a system of transferable carbon credits if governments do not establish ownership rights to carbon and if private property rights are not enforceable and upheld by the courts. If forestland ownership and forest exploitation have been in public hands (as in much of Canada), government agencies and ENGOs will oppose their privatization. There will also be greater support for public afforestation programs, particularly if the purpose is both to supply nature (enhance biodiversity) and sequester carbon.

Each of the coordination mechanisms has its potential strengths and weaknesses. Control is often the path of least resistance for governments: the government enhances the size of carbon sinks by requiring landowners to plant trees on some portion of their land.[1] Control can be justified on efficiency grounds if there are savings in transaction costs that exceed the gains from using another means for achieving the C sink objective, or there are economies of scale and scope that would not be realized otherwise. For example, if trees are to be used in a biomass burning facility, economies of scale may not be realized unless a certain minimum area of agricultural land near the facility is converted to trees. Economies of scope occur because it may be more efficient to provide two amenities, say commercial timber benefits and extra-market amenities (C uptake and storage), together rather than separately. The state can guarantee that such economies are realized.

The state could also purchase land and plant trees itself, but then incentives are lacking to minimize costs (Shleifer 1998). Alternatively, the state could enter into agreements with landowners to produce tree-planting (C-uptake) services. This situation is discussed further in the context of contracts.

Clearly, government will prefer to provide the desired C-uptake services at little or no cost to the public treasury, which is why states have a proclivity for regulation (e.g., mandating landowners to plant trees). The main advantage of control is that society is more certain that the desired good or service is supplied. However, control also has its disadvantages (e.g., rigidity, lack of experimentation).

Private provision only occurs if the state uses broad-based incentives or contracts to obtain desired levels (supply) of afforestation. However, even if society relies solely on competition and markets, there is still a role for government. The state needs to establish the market for carbon offsets (e.g., by separating the right to carbon from the right to the trees), so that the landowner can sell offsets annually at whatever the market will bear. A carbon tax/subsidy scheme can also be used to provide the correct incentives to landowners (van Kooten et al. 1995). In addition, futures and insurance markets could be used to provide some protection against political whims and the vagaries associated with the production of carbon uptake that are inevitable due to future uncertainty about growth, fires and disease, and carbon and fiber prices.

One advantage of reliance on competition to provide terrestrial C-sink services is that society may get greater diversity in the types (qualities) of sinks provided, particularly if wood product sinks are permitted and/or biomass burning becomes increasingly attractive. Competition encourages cost minimization, making domestic terrestrial carbon sinks more competitive with CDM and JI projects. On the negative side, competition may inhibit economies of size and scope. Further, uncertainty and lack of commitment may characterize competition, with land use apt to return to the original agricultural use if appropriate market institutions (e.g., markets for C offsets, future/insurance markets) are not in place. A country cannot know with any degree of certainty at the time it implements this coordination mechanism how much carbon offsets are available at some future commitment period.

For cooperative exchange, and common values and norms, enforcement is a problem, while commitment is a strength.

4. Contracting to Plant Trees

Contracts will vary by the quality of nature desired (say, native species versus hybrid poplar), local institutions and the costs of providing different forms of nature, and the ability to reallocate funds from demanders of nature to suppliers. Contracts refer to the "arrangements" between the "principal" who demands the nature and the "agent" who supplies it. The typical principal-agent model assumes the principal maximizes some objective function subject to the agent's utility constraint (Hart and Holmström 1987; Sappington 1991). In the case of tree planting on agricultural land, the principal may be either the government or a private agency (e.g., an ENGO, a utility company or forestry firm), while the agent is the landowner. The principal has several options for producing carbon credits:

(1) purchase the land and provide all of the associated forestry services (planting, tending, harvesting and hauling);[2]
(2) contract with the landowner over the relevant period, with one of the parties responsible for the associated forestry services; and/or
(3) contract to purchase annually carbon offsets from the landowner at agreed upon prices, with the landowner responsible for the production of C credits.

Clearly, option (1) is identical to public ownership (discussed above) or some other situation where the externality is internalized. As with the market option, under (3) the landowner encounters no incentive problem but also bears all of the risks.

Option (2) is some middle ground between (1) and (3). For option (2), contracts are involved explicitly. By "hiring" the landowner, the principal may suffer from possible shirking on the part of the agent. Shirking consists of activities that are difficult to monitor but reduce potential carbon uptake. It includes selective harvesting of trees for personal use, not policing against selective logging by outsiders, lack of vigilance in preventing fire, and permitting cattle onto lands planted to trees (thus slowing tree growth). However, depending on the terms of the contract, under option (2) the principal no longer bears the full risk of the undertaking. Clearly, in order to maximize the payoff, the principal must adopt appropriate contractual forms with built-in incentive schemes that induce behavior on the part of landowners that "best" coincides with the objectives of the principal. Therefore, a typical principal-agent model generates a trade-off between risk avoidance and incentive implications, with most assuming risk neutrality for the principal and risk aversion for the agent.

Transaction costs and contracting

The objective of the principal is to choose one or more contractual forms that economize on transaction costs (e.g., a lease agreement with the principal performing forestry activities, or an agreement to purchase a certain amount of C-uptake services each year). Transaction costs are the costs of capturing and protecting property rights, and transferring them from one agent to another. They include "the costs of discovering exchange opportunities, negotiating contracts, monitoring and enforcing implementation, and maintaining and protecting the institutional structure" (Pejovich 1995, p.84). Transaction costs consist of the cost of arranging a contract *ex ante* and monitoring and enforcing it *ex post*, as opposed to production costs, which are the costs of executing a contract.

There are three sources of transaction costs (Pejovich 1995, pp.84-87). First, there are search costs related to finding potential suppliers of land (and buyers of carbon offsets, if necessary), obtaining information about their behavior and circumstances, and getting information about expected growth rates of trees on land to be converted to forest.

Second, bargaining is an essential element of the contracting process, so there are negotiation costs (Kostritsky 1993). Negotiation can be thought of as a process for achieving common understanding of the main attributes of the contract and reaching agreement about the obligations of the respective parties to the contract. Naturally, there are benefits of repeated contracting, because economic agents gain experience (and information) over an extended period of time, modifying their behavior not only in their own interest but also out of consideration of the relationship that evolves over time. This is why "relational" contracts have gained popularity, because they contain provisions that allow for readjustment in the allocation of risks as circumstances change.

Opportunities for repetitive contracting are limited for Canadian terrestrial carbon sinks because it will take 15 or more years for trees to reach maturity. In lieu of repeated contracts and explicit markets for carbon offsets, landowners may decide to cooperate in the sale of tree-planting services. This may be important because many farmers have experience with cooperatives (e.g., grain coops are common across the Canadian prairies) and there may be only one or a few buyers of C-uptake services (generally a large utility or the state). If landowners cooperate in the sale of carbon offsets, they are in a better position to undertake planting, harvesting, fire protection, monitoring and other forestry activities, with cooperatives likely investing in specialized assets to do so.

Finally, contracts need to be prepared and monitored to ensure that the parties to a contract abide by its terms. There is the need to enforce a contract and collect damages when partners fail to observe their obligations, and property rights must be protected against third-party encroachment.

Incomplete contracting

A traditional view is that no contract can be formed until clear and complete agreement is reached, but such a contract would need to provide for all contingencies and specify comprehensively the time, price, quantity and quality of performance (Kostritsky 1993). The perfectly contingent contract assumes highly rational actors capable of bargaining, at reasonable costs, to allocate explicitly all future risks associated with the undertaking. In the real world, contracts are incomplete because some terms are unspecified due to the costs of negotiation and information gathering. With informational barriers and uncertainty about the future, comprehensive contracting is not realistic since humans are boundedly rational and act in their self-interest with guile. Contracting agents may intend to behave rationally, but are limited as to what is possible – they have a finite (unknown) capacity for knowledge, understanding and reasoning, and they cannot foresee all possible future contingencies. Incomplete contracting raises transaction costs.

Transaction costs related to incomplete contracting can be a major barrier to contracting, particularly in the case of tree planting where there is a great deal of uncertainty. Recognizing limits on rationality helps explain why parties may initially fail to agree (e.g., landowners demand outlandish compensation). Nonetheless, incomplete contracts are common in the real world, mainly because the parties to the contract recognize the existence of uncertainty and are flexible enough to leave some items (contingencies) to be resolved at some future date. In some cases, the courts may intervene to resolve incompleteness, while in others incompleteness is resolved through negotiation. It is worth noting that the owner of assets often has greater bargaining power in situations where contracts are vague, not specifying what needs to be done in all circumstances (Hart and Moore 1990). This explains why landowners may wish to form cooperatives that sell tree-planting services to the state or some other entity.

Finally, while factors such as bounded rationality and the problem of information constitute barriers to fully contingent contracts, resulting in incomplete contracts, opportunism tends to result in shirking (noted above), making policing more difficult. Appropriate incentive structures help ensure that the actions of the agent are in the principal's interest, and contracts must be enforced so that gross violations do not occur. Features such as contract length and contract detail address these potential problems. Repeated contracting can help in this regard because violators will lose future contracts, but this is unlikely for terrestrial carbon sinks as already noted, while it is an empirical matter whether landowners will enter into contracts exceeding 15 years. The familiar hypothesis that the principal and agent maximize the expected value of the contract only holds *ex ante*, as *ex post* each party will focus on their individual interest and try to appropriate as much of the individual gain as possible on each occasion. Thus, it may be understood that incentive enhancing is possible through *ex ante* alignment, whereas hazard mitigation is mainly achieved through *ex post* governance of incomplete contracts (Williamson 1998).

Framework for reducing transaction costs

Transacting costs can be large relative to gains because of natural difficulties in trading or they can be large for legal reasons. Transaction costs may be reduced at various levels by the state, the principal (which might also be the state) and the agent. When transaction costs are low, market trading or contracts between private firms and landowners, as opposed to state provision, are the preferred means for developing terrestrial carbon sinks on agricultural land. If transaction costs are high, markets or private contracting may be less successful and state involvement (perhaps even state provision) may be required. Each party can choose to uphold the contract terms or compensate the other party for damages; this is efficiency enhancing because it reduces transaction costs by preventing opportunistic behavior (Pejovich 1995).

Within the general framework of contractual relations, a number of schemes hold promise for lowering transaction costs (Kostrisky 1993). First, contracts can contain a generalized “default” rule that permits implicit bargaining. The advantage of such a rule lies in reducing the costs of negotiating every detail (obligation) at the outset, allowing for the determination in the future of some specific terms and duties. Where uncertainty about what will constitute optimal behavior at the time of performance may be significant, it is a good idea to leave aspects of that performance open to negotiation rather than constrain parties to specific but potentially inappropriate actions. For instance, long-term contracts often contain provisions for periodic adjustments of prices; removing carbon from the atmosphere may become more or less urgent as more information becomes available or as countries reach a carbon agreement that is binding, so renegotiations become an important component of the contract. Contracts with built-in renegotiation clauses are considerably simpler than contingent claims contracts. It is then that principals and agents gain trust. Indeed it is ideal to have agreements that remain flexible in the face of changing circumstances, relying on trust to smooth out differences.

Second, it may be necessary to include in a contract a reasonable level of detail to minimize opportunistic behavior, although some scope for opportunism inevitably remains and, therefore, only limited success may be expected from planning in advance.

Finally, with an understanding of the role of transaction costs, it becomes a legitimate concern to inquire about the level of transaction costs in a given institutional environment. Transaction costs can be reduced by choice of an appropriate governance mode. For example, market oriented contracting usually prevails when nonspecific investments are involved. As asset specificity increases, market arrangements tend to give way to bilateral contracts (Williamson 1985).

One of the important reasons for writing C-sink contracts is to guard against the hazards inherent to changes in land use that span 15 years or more. Contracts protect landowners who invest in specialized assets that are related directly to tree planting (viz., equipment used in forestry) or indirectly because remaining farmland is used differently as a result of converting some proportion of the farm to forest (e.g., investment in intensive livestock rearing). If adequate performance guarantees or incentives are included, it gives some assurance to the principal that the contracted amount of CO_2 will indeed be removed from the atmosphere.

As noted in the introduction, Canada intends to rely on afforestation of marginal agricultural land for a significant part of its international commitments to mitigate climate change. Therefore, in the next section, we investigate the reaction of landowners to potential institutions and incentives to get them to contribute land for this purpose. Our objective is to determine whether there are obstacles that increase transaction costs so that what might seem to be a reasonable LUCF project is indeed more costly than some alternative.

5. Some Empirical Evidence

Data for the analysis were obtained from a mail-out survey of farmers in Canada's grain belt region using addresses compiled by Watts List Brokerage, a firm that maintains mailing lists related to agriculture. According to the firm, its "Canadian Farmers" database – the largest and most comprehensive database of farmers in Canada – is updated quarterly exclusively from survey and research sources, so the most current and accurate information are assured. After omitting farmers with less than 160 acres of land, the database consists of 34,618 farmers in western Canada, out of which a random sample of 5000 names was purchased. Due to cost considerations, a random sub-sample of 2000 farmers was employed. The survey was sent out in July 2000, with postcard reminders following after approximately three weeks. Unfortunately, the Watts List Brokerage database was less reliable than the company claimed, with a large number of surveys returned as undeliverable because farmers were deceased or had left farming. A total of 208 surveys were returned for a response rate of 13%, but only 182 surveys were usable. This response rate compares favorably with the 12% response rate reported by the Environics Research Group (2000) and Bell et al. (1994) in surveys of Canadian and American farmers, respectively. Further details of the survey and response rates are found in Suchánek (2001).

Survey respondents were given the following information:

> "Carbon credits are earned by increasing removal of CO_2 from the air and storing it in plant material. Farmers create carbon credits by planting trees on their land, converting cropland to grassland, and/or reducing tillage operations. The size of credits is determined by the increases in tree biomass (i.e., faster growing trees remove more CO_2 from the atmosphere, thereby generating larger carbon credits), crop residues and soil organic matter brought about by the action, with monitoring done by an environmental non-governmental or governmental agency. Farmers could sell carbon credits on carbon markets that are now being developed. Alternatively, farmers could exchange their carbon credits for subsidies (from government, industry, etc.) to engage in the activities that provide the carbon credits – ownership of the carbon credit is effectively transferred to another party."

Nearly 75% of survey respondents indicated a willingness to create carbon offsets if they could somehow sell carbon credits or if they were adequately compensated. However, they expressed substantially different preferences for the types of land use changes they were willing to implement in order to create carbon offsets. As indicated in Table 1, less than one-quarter of farmers indicated they were willing to plant large blocks of trees, even if they could sell the carbon so that they were fully compensated for lost revenues. The majority of respondents considered planting trees only in the limited case where they could earn C offsets for planting shelterbelts or individual trees. (While 110 respondents had experience with tree planting, 104 had planted shelterbelts and 52 individual trees, but only 6 large blocks of trees.) More than 60% of respondents indicated that they would reduce tillage operations, and about 55% would reduce summer fallow intensity (increase years that the land is in crops), if they could recoup the added costs by selling carbon credits. Each of these activities increases soil organic matter, as does chemical fallow, an option considered by only a minority of respondents.

Overall, these responses indicate that farmers prefer carbon sink options that they are most familiar with and that have long been recommended by soil scientists as means for reducing soil erosion (Lerohl and van Kooten 1995).[3] It is not going to be easy to get farmers to adopt tree-planting programs on a scale needed to meet a significant component of Canada's Kyoto target. Farmers' preferences for other carbon sinks (not yet permitted under Kyoto) are probably conditioned by their experience, by the recent emphasis on agricultural soil sinks, and by the fact that some (albeit limited) areas of the prairie region are unlikely to be suited for growing trees without irrigation.[4] It remains our contention that the major obstacle will be to convince farmers to plant trees, with the success of so doing dependent on the institutions and incentives that are to be used.

Survey respondents appear to be quite familiar with contracts, as indicated in Table 2. Indeed, 62% indicated that they have had crop share or lease agreements, as a renter, landowner or both. However, fewer have experience with land-use restrictions that prevent crop production (5.5%), such as leases to keep wetlands out of crop production (viz., Prairie Pothole Project), or restrict crop practices (9.3%), such as agreements that prevent haying before a certain date. Contracts restricting land use ranged in length from 1 to 10, 25 and even 30 years (Figure 1), within the range required for tree planting.

Respondents were asked to compare four governance structures for establishing carbon sinks (Table 3). In choosing the mechanisms, we ruled out the control option (regulation and outright government purchase of land) as politically infeasible. Surprisingly, landowners expressed a preference for tree-planting contracts over a pure market mechanism that would enable them to sell offsets without interference. However, landowners appear reluctant to enter into contracts with environmental NGOs, preferring to work with governments or even large companies that need to purchase carbon offsets.[5] This might be the case because farmers have experience dealing with government through a plethora of agricultural programs, although this does not explain the proclivity towards contracting with large private companies. The only explanation that comes to mind is that respondents may have had experience in dealing with companies that needed to access oil wells or oil and gas pipeline corridors.

Using survey data summarized in Table 3, a market preference variable was constructed to investigate the role of asset specificity and experience with contracts as possible explanations of a preferred governance structure. This variable takes on a maximum value of 1.0 for an individual who would rank markets as the most preferred option followed, in order, by contracts with private firms, with ENGOs and, last, with government; it takes on a value of zero for precisely the opposite ranking.[6] The value of the market preference variable ranged from 0 to 0.91, and averaged 0.42; it was regressed on various explanatory variables. The log-odds OLS regression results are provided in column 1 of Table 4. They indicate that previous experiences with contracts that require farmers to restrict land use or cropping practices are insignificant explanatory variables. Such contracts were probably with a state agency, and not a private firm, such as an oil company, for which no information is available. Number of cattle is an indicator of one type of asset specificity (e.g., cattle trucks), while net worth is an indicator of the extent to which the respondent owns other specific assets (primarily land, but also tractors, combines, etc.). Only net worth is statistically significant, with those with higher net worth more likely to prefer market-type instruments over other governance forms.

Respondents were asked whether they would even consider large-scale tree planting if they were adequately compensated. Out of 177 respondents who answered this question, 45 indicated they would not consider planting trees. In an attempt to determine factors that might explain responses, a logit regression model was employed, with results provided in column 2 of Table 4. The only statistically significant variable that explains why farmers would agree to plant trees if adequately compensated is whether or not they are located in the black soil zone. Surprisingly, those in the black soil zone where conditions for tree growth are likely best (as it borders the boreal forest) would be less likely to agree to large-block tree planting even if they were adequately compensated. These are also the individuals most likely to be near sawmills or pulp mills and to have had recent experience with land clearing (not asked in the questionnaire).[7] Clearly, improving land by removing trees is considered a costly proposition from both a financial and perhaps utility point of view. As a result, farmers are not keen to reverse this process.

When asked about preferences concerning the length of a potential tree-planting contract, survey respondents overwhelmingly chose contracts that did not exceed 20 years (Figure 1). Upon regressing stated contract length on available explanatory variables (see column 3, Table 4), only two variables turned out to be statistically significant. Farmers located in the black soil zone preferred shorter contracts (probably so that trees did not get "too established" and thus difficult to remove), as did those who expressed a greater proclivity for relying on markets to sell carbon credits (as measured by the market preference variable). Surprisingly, asset specificity, as measured by numbers of cattle and area farmed (in lieu of net worth) were not statistically significant in explaining preferred contract length; nor was experience with other contracts that resulted in land use changes.

Finally, nearly 82% of respondents answered "yes" to whether they would join a cooperative to sell carbon-offset services. This high proportion of yes responses is because farmers in western Canada have a great deal of experience with cooperatives. They market their grain (and often livestock) through cooperatives (actually pooling agents), such as the Saskatchewan Wheat Pool, Alberta Wheat Pool and Canadian Wheat Board, while they purchase many inputs (including groceries) at a coop. This might explain why a logit regression model failed to identify any variables that might explain preference for cooperating to sell carbon credits.

6. Discussion

While landowners in Canada are in a position to help the country achieve carbon emissions reduction through large-block tree plantations, the results of this study suggest that getting farmers to do so may be a hard sell. Even if they are fully compensated for lost agricultural revenues and tree planting costs, our survey results indicate that more than one-quarter of farmers would be unwilling to enter into an afforestation program voluntarily.

Rather, the evidence suggests that landowners are content to change cropping practices in ways that provide some, albeit much smaller, carbon benefits, whether that consists of planting shelterbelts and individual trees or changing cropping practices so that more organic matter is stored in soils. Less than 1/4 of survey respondents consider large-block tree planting even to be an effective means for producing carbon credits, compared to much higher proportions citing other agricultural activities (Table 1).

Importantly, these other activities provide benefits, such as reduced wind erosion or greater soil fertility, in addition to those associated with carbon uptake. Even then landowners demand or expect to be compensated.

It appears that there may be unaccounted for transaction costs that prevent large-scale tree planting on marginal agricultural lands in Canada. While usual economic analyses of tree planting indicate that, compared to energy alternatives, say, it is a cost-effective means for achieving carbon offsets, our results indicate that there may be unknown transaction costs that could raise costs considerably. As indicated, farmers are reluctant to make dramatic changes to the way they use their land; they prefer to continue with what they know best, and current agricultural policies, programs and research (e.g., with respect to soil carbon sinks) entrench such behavior. Further, there is some (albeit limited) evidence that asset specificity, in the form of developed land and investments in combines, tractors, fencing and trucks, may be an obstacle to afforestation, at least in the minds of farmers. Finally, the great majority of farmers would not be willing to enter into tree-planting agreements that exceeded about 15 years, the rotation age for hybrid-poplar (see Figure 1). This militates against programs to plant native tree species for biodiversity reasons, since such trees have a rotation age of some 40 years or more.[8]

Table 1: Strategies for Production of Carbon for Sale: Percent Responding "Yes"

Strategy	**%**
Reduce tillage operations	60.7
Replace tillage summer fallow with chemical fallow	47.4
Reduce summer fallow by increasing cropping intensity	54.1
Plant fast-growing trees in large blocks	23.7
Plant native trees in large blocks	20.7
Plant shelterbelts and/or individual trees	57.8

Table 2: Survey Respondents' Experience with Various Contracts

Type of contract	No. of respondents	% of respondents
Land-use restriction that prevents crop production	10	5.5%
Restriction on cropping practices	17	9.3%
Crop share or lease agreement	113	62.1%
– as renter	104	57.1%
– as landowner	68	37.4%
Other	6	3.3%

Table 3: Respondents' Ranking of Governance Structures for Establishing C Sinks

Governance structure	Normalized Rank
Tree-planting contracts with government/state agency	1.00
Tree-planting contracts with private firms (large CO_2 emitters)	0.87
Sell C credits in markets established to allow trade	0.71
Tree-planting contracts with ENGOs	0.44

Table 4: Regression Results[a]

Explanatory variable	(1) Log-odds [b]	(3) Logit: Yes to planting	(2) Length of Contract
Constant	-1.8086	1.3490	12.1470
	(-3.030)	(5,216)	(1.648)
Net worth	0.0017		
	(2.015)		
Land base			-0.0004
			(-0.576)
Number of cattle	0.0005		0.0016
	(0.712)		(0.634)
Age of operator			0.169
			(1.497)
Preference for markets if selling carbon credits			-6.268
			(-1.69)
Farm located in black soil zone		-0.6436	-3.999
		(-1.835)	(-2.020)
Experience with contracts that:			
Restrict land use	-0.5811	1.1454	0.573
	(-0.539)	(1.083)	(0.158)
Restrict crop practices	-0.8676		
	(-0.989)		
R^2	0.0691	0.041[c]	0.1577
No. of observations	92	177	83

[a] t-statistics or asymptotic t-statistics are provided in parentheses.

[b] Dependent variable is $\ln\left(\frac{y}{1-y}\right)$, where y is the market preference variable, and OLS regression is used.

[c] Cragg-Uhler R^2; likelihood ratio = 5.000 with 2 df

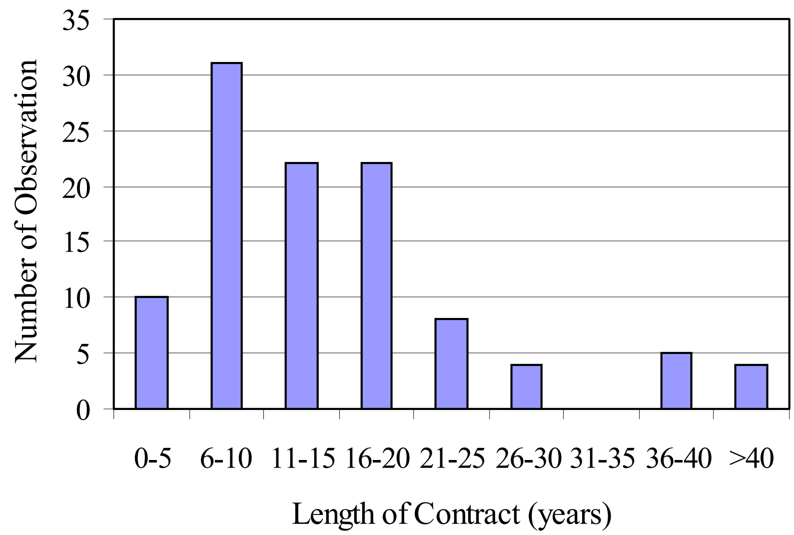

Figure 1: Respondents' Stated Preferences for Length of Tree-Planting Contracts

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ENDNOTES:

[1] It may be required for the landowner to remain eligible for agricultural programs, say, but a stronger regulatory fist can also be used. In Denmark, for example, landowners are prohibited by law from converting forest to agriculture, which has discouraged participation in EU tree planting programs.

[2] Of course, the principal could sub-contract with silvicultural and logging contractors to have these associated services provided, but this is beyond the current discussion (see Wang and van Kooten 1999).

[3] Nine respondents indicated that they already had reduced tillage operations and/or employed chemical rather than tillage summer fallow, while six had employed continuous cropping for a long time (10+ years). Two of the operators felt they should be able to claim retroactive carbon credits, while three additional respondents asked specifically about getting C credits as a result of zero or minimum tillage operations.

[4] Seven respondents indicated that their land was not suited for growing trees, while two suggested that trees were not native to the prairies (although certain species can survive, even in the driest areas).

[5] Four respondents specifically noted that they did not trust the government to honor its contracts, indicating that states can change the terms of a contract as they please.

[6] Respondents ranked the four items in order. A value of 3 was assigned to the highest ranked item and 0 to the lowest; in the case of ties, the average of the two rankings was used.

[7] Landowners in the black soil zone do not appear to have more trees on their land than those in other regions, with the correlation between proportion of land covered by forest and the black soil zone dummy variable being 0.0288.

[8] The Canadian government is likely to implement a tree-planting program for marginal agricultural land that employs native tree species (pers. comm., T. Lempriere, Canadian Forest Service, July, 2000).