Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Cost-efficiency analysis of possible environmental goods and services (EG&S) policy options

Canada

Catalogue No. A125-13/2011E-PDF
ISBN 978-1-100-19316-8
AAFC No. 11613E

Cost-Efficiency Analysis of Possible Environmental Goods and Services (EG&S) Policy Options

Final Report

Prepared for:
Agriculture and Agri-Food Canada

December 30, 2008

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ÉcoRessources Consultants, a firm based in Quebec City, submits this report in partnership with the International Institute for Sustainable Development (IISD) and the Institut de recherche et de développement en agroenvironnement (IRDA).

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Executive Summary

Purpose:

This report estimates the costs and benefits of several policies that could increase the supply of ecological goods and services (EG&S) from agricultural land in Canada. The following options were analyzed: annual payments, one-time payments, reverse auctions, and water quality trading. These options are similar to programs under consideration for EG&S in Canada. Annual payments are used in the Conservation Reserve Program (CRP) in the United States, and the Alternate Land Use Service (ALUS) project is used in Manitoba. One-time payments are a key tool of Canada's National Farm Stewardship Program (NFSP). Mixes of annual and one-time payments are being considered under the Growing Forward Framework for agricultural policy. Reverse auctions are currently used in Australia and are being tested in western Canada. Water quality trading is used in eastern Ontario and several areas of the United States.

These policy options can all increase the adoption of beneficial management practices (BMPs) that increase EG&S. The BMPs covered in this study include grassy and wooded riparian buffer zones, winter cover crops, conservation tillage, conversion of marginal farmland to wetland, retirement of flood-prone land, conservation of existing forests and wetland, and manure storage.

Caution:

Please note that measurements of the value and cost of ecological services should be treated with caution. The following estimates are very approximate and have a large margin of error. This large margin of error is due to uncertainty at several stages of the estimation process, including the impact of particular BMPs on nutrient levels, the costs to producers of adopting BMPs, the value that residents of a watershed place on environmental improvements, and the extrapolation of results from two local areas to provincial and national levels.

Methodology:

The report quantifies the costs to producers of certain practices and proposes a payment schedule to offset these costs; it also estimates public administrative costs. The programs are designed to achieve a target level of two environmental benefits: a reduction of phosphorous concentrations in surface water and the maintenance or enhancement of wildlife habitats. The analysis is conducted for two representative watersheds, the Nicolet (East) sub-watershed in Quebec and the Little Saskatchewan River watershed in Manitoba, and aggregated to the provincial and national level. The benefits of BMP adoption are given a dollar value through "benefit transfer" methodology. Total public costs of each policy are compared to the benefits in order to obtain benefit-cost ratios.

Key Results:

Improvements in water quality worth approximately $900 million would cost between $500 million and $2.5 billion:

A program focused on decreasing phosphorous loadings in water from agricultural sources across Canada to recommended levels would provide benefits to local populations worth approximately $900 million. These benefits include increased fishing, recreational activity, and less expensive water treatment. The costs of attaining this improvement would be approximately:

- $2.5 billion, if delivered through an annual payment policy;
- $1.2 billion, if delivered through a one-time payment policy;
- $ 900 million, for an optimal mix of annual and one-time payments;
- $ 600 million, if delivered through a reverse auction tool; and
- $ 500 million, if delivered through a water quality trading system.

An EG&S program that improves both wildlife habitat and water quality would provide at least $3.3 billion in benefits and would cost between $1 billion and $2.8 billion:

Increasing wildlife habitat in addition to achieving targeted lower phosphorous levels in water at a national scale could be worth between $3.3 billion and $3.9 billion to the inhabitants of the affected regions in terms of improved recreation, drinking water, flood protection, aesthetics and other public benefits. Achieving these results for Canada would cost approximately:

- $2.8 billion, if delivered through an annual payment policy;

- $1.5 billion, if delivered through a one-time payment policy;
- $1.2 billion, for a mix of annual and one-time payments; and
- $1 billion, if delivered through a reverse auction tool.

Water quality trading cannot be compared to these options because it cannot be used directly to increase wildlife habitat.

Implications:

Market-based instruments are much more efficient than uniform payment programs. To obtain similar benefits, programs that use standard payment schedules, such as annual or one-time payments, are two to five times more expensive than market instruments such as auctions and water quality trading.

Water quality trading is the most efficient of the tools examined. However, while suitable for reducing phosphorous loadings, it is not suitable for increasing other ecological services, such as wildlife habitat.

One-time payments are suited to actions that involve an initial investment and low on-going costs, such as grassed buffer strips, conversion to conservation tillage or manure storage facilities. On-going payments are suited to actions that involve significant recurring expenditures, such as wooded buffer strips and seeding winter cover crops. The BMPs that reduce phosphorous levels most efficiently can be supported by one-time payments. This is mainly because the BMP "grassed riparian zones", which is suited to one-time payments, is much less expensive than "wooded riparian zones", which are more suited to annual or on-going payments.

Some BMPs are far more efficient than others. For example, the costs of reducing phosphorous in eastern regions are approximately:

- $38/kg for cover crops;
- $183/kg for grassed riparian buffers;
- $402/kg for reduced tillage and no-till; and
- $897/kg for wooded riparian buffers.

The costs of reducing phosphorous in the western regions are about:

- $19/kg for grassed riparian buffers;

- $41/kg for manure storage;
- $224/kg for wooded riparian buffers; and
- $263/kg for cover crops.

In addition, the efficiency of BMPs may vary enormously between regions, as cover crops are very efficient for phosphorous in the east but are inefficient in the west. These differences depend in part on differences in opportunity costs between regions for certain BMPs.

Water quality costs more to improve than wildlife habitat. Based on the value to the public of improvements in water quality and wildlife habitat, it costs much more to obtain reductions in phosphorous levels in water than to obtain equivalent increases in value for wildlife habitat.

Provincial results for water quality improvements:

The benefits and costs of implementing the phosphorous reduction policy described above would be distributed as indicated in the following table. (See full report for other provincial results.)

Public Costs for phosphorus reduction, by province

Province	*Total benefits* ($ millions)	*Costs: ($ millions)*				
		1-time payments	Annual payments	Mix: Annual and 1-time payments	Auctions	Tradable permits
Prince Edward Island	4	18	25	18	14	10
Nova Scotia	27	10	17	10	5	4
New Brunswick	20	14	20	14	9	7
Quebec	229	210	369	213	152	114
Ontario	337	426	735	432	297	223
Newfoundland and Labrador	14	NA	NA	NA	NA	NA
Manitoba	32	78	192	27	19	17
Saskatchewan	28	249	636	69	51	46
Alberta	93	197	454	96	61	55
British Columbia	119	13	23	10	6	5
Canada	903	1 214	2 472	889	613	480

Quantitative Results

Total public costs for all policies and both regions, split by environmental objectives (water quality and wildlife habitat) are summarized in the next table. These costs show that in both regions and for the whole country, the cost of implementing policies based on pre-determined government payments is significantly higher than the cost of implementing market-based instrument policies. Moreover, costs required to reach the water quality improvement target are greater than the costs needed to preserve wildlife habitat.

AGGREGATED TOTAL PUBLIC COSTS FOR CANADA

	One-time payments (million $)		**Annual payments** (million $)		**Mixed one-time/annual payments** (million $)		**Auctions** (million $)		**Tradable permits** (for P only) (million $)	
	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada
Total water costs	677	536	1,166	1,306	687	202	477	136	358	123
Total habitat costs	315	43	317	54	319	61	391	62	-	56
Total costs[1]	**992**	**536**	**1,483**	**1,306**	**1,006**	**202**	**868**	**136**	**358**	**123**
	1,528		**2,789**		**1,208**		**1,004**		**481**	

The results obtained are consistent with economic theory and with research literature on policy efficiency and design. Policies based on market-based instruments (auctions and permit trading systems) are more efficient than direct payment policies (one-time, annual payments and a mixed policy of one-time and annual payments). However, market-based mechanisms entail higher public transaction costs per dollar of payment.

[1] In the case of Western Canada, some BMPs that have an impact on water quality also improve the habitat, and there is no BMP specific to habitat that is not taken into account for water quality. This is why total payments equal the payments for water quality improvement.

Summary Report

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1. INTRODUCTION

Federal and provincial departments of agriculture in Canada are currently examining policy options based on the concept of Ecological Goods and Services (EG&S), also known as ecosystem services and multi-functionality. The definition of EG&S for federal/provincial (F/P) policymakers is derived from the UN Millennium Ecosystem Assessment of 2005:

"*Ecological Goods and Services (EG&S) are the positive environmental benefits that Canadians derive from healthy ecosystems, including clean water and air, and enhanced biodiversity. The EG&S concept includes market goods produced from ecosystems (e.g. food, fibre, fuel, fresh water, generic resources, biochemicals, etc.), the benefits from ecosystem processes (e.g. nutrient cycling, climate regulation, water purification, waste treatment, pollination, etc.) and non-material benefits (e.g. aesthetic values, recreation, etc.) Agriculture is both a beneficiary and a provider of EG&S. For example, farming's viability depends on ecosystem processes like soil renewal, climate regulation, and precipitation. At the same time, well-managed agricultural lands can provide benefits to broader society like fish and wildlife habitat, scenic views, and purification of air and water through natural processes.*"

There are differing opinions among governments on the efficiency and effectiveness of various EG&S policy tools for potential integration into future agri-environmental programming. In the face of pressure from some in the agricultural industry to increase subsidy levels through environmental programming under the heading of EG&S, with strong support from some provinces and equally strong resistance from others, consensus was achieved among F/P Ministers to have officials undertake research on EG&S policy. As a result, the F/P EG&S Working Group was formed.

In late 2006, Ministers directed officials to conduct a cost-benefit analysis (CBA) of potential EG&S options in Canada. The F/P EG&S Working Group formed a sub-committee consisting of five representatives from Agriculture Agri-Food Canada (AAFC) and five provincial members (Manitoba, Ontario, Alberta, Saskatchewan, and Quebec) to handle the CBA contacting process and subsequent monitoring. As a result, ÉcoRessources Consultants and their partners, the International Institute for Sustainable Development (IISD) and the Institut de recherche et de développement en agroenvironnement (IRDA), were awarded the contract to estimate the efficiency of the various EG&S policy tools selected by the F/P Working Group through a cost-benefit analysis.

This report estimates the costs and benefits of five beneficial management practice (BMP) incentive programs: one-time payments, annual payments, mixed one-time and annual payments, auctions and tradable permits. The five programs were designed to achieve a certain target level of environmental benefits. The desired environmental benefits were a reduction of phosphorous concentrations in surface water and the maintenance or enhancement of wildlife habitats. The analysis was conducted for two representative watersheds: the Nicolet (East) sub-watershed in Quebec and the Little Saskatchewan River watershed in Manitoba.

Regarding the analytical methods employed for the study, specific BMPs selected for analysis differ for each watershed and incentive policy. This exercise was carried out using a method that involved quantifying the private costs of certain practices to producers and then designing a payment schedule to offset those costs. Total public costs of each policy were compared to the level of benefits that are given a dollar value via the benefit transfer method. Through this method, a ranking of the five policies, with respect to the benefit-cost ratio generated by each of them, was obtained. Finally, cost and benefits were extrapolated to two regions: Central and Eastern Canada and Western Canada. The ranking of the five policies was re-evaluated at the level of these two regions in order to derive conclusions useful to all Canadian provinces.

2. POLICY OPTIONS

This report takes an in-depth look at various types of policies to determine their efficiency in producing least-cost environmental goods and services. These policies consist of one-time payments, annual payments, a mixed policy of one-time and annual payments as well as market-based instruments in the form of auction mechanisms and emissions trading schemes.

The policy scenarios chosen owe much to existing agri-environmental programs such as the federal government's National Farm Stewardship and Greencover Canada programs, Manitoba's Alternative Land Use Services (ALUS) program , Quebec's Farm Income Stabilization Insurance (FISI) and various other provincial on-farm environmental planning programs. We also made use of existing programs in other countries such as the USA's Conservation Reserve Program (CRP), Australia's BushTender and EcoTender programs and France's agri-environmental measures (AEMs).

The primary purpose of these policies is to encourage adoption of beneficial management practices (BMPs) to achieve target environmental goods and services (EG&S). Selecting the portfolios of practices that will qualify users for payments is thus a central part of the policy design process, and policy efficacy will depend on this aspect to a great extent.

2.1. One-time Payments:

The aim of this policy is to encourage implementation of certain BMPs by one-time payments covering all the net losses incurred by farmers who comply with their contractual commitments. Under this policy, producers undertake to implement BMPs on their farms in exchange for one-time financial compensation.

The BMPs that make up our one-time payment policy portfolio are: grassy riparian buffer strips (without maintenance), cover crops for cereals, conservation tillage and direct seeding, maintaining woodlands and wetlands in agricultural areas, crop reduction on agricultural floodplains, and manure storage.

The payment level corresponds to a certain percentage of the value of the investments made up to a predetermined limit. In the case of maintaining woodlands and wetlands in agricultural areas and of crop reduction in agricultural floodplains, the payment level represents the capitalized amount of the opportunity cost associated with use of the land. In terms of technical support, the one-time payment corresponds to the cost of technical assistance for two years.

2.2. Annual Payments:

The annual payment policy involves awarding financial compensation to program participants for all the net annual expenses incurred by implementing BMPs on their farms. The portfolio of BMPs qualifying for the annual payment program thus consists of practices that involve recurring expenses, i.e., establishing treed buffer strips (with maintenance), cover crops, intercropping, maintaining woodlands and wetlands in agricultural areas, and crop reduction on agricultural floodplains.

As in the case of one-time payments, all farmers are generally eligible for the program for all their owned or leased land. However, in the case of certain practices requiring an initial investment, only owned land qualifies.

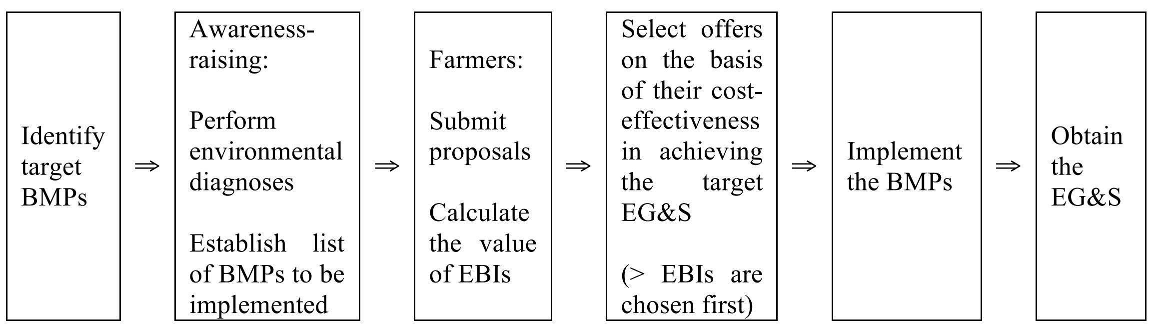
The contract period is for three years and can be renewed twice, i.e., up to a total of nine years. In terms of penalties, producers who do not fulfil their contractual commitments will not receive assistance for the year in question, and producers wishing to terminate their contracts before expiry will be required to repay half the annual amount of the remaining years (penalty modelled on the ALUS and Greencover Canada programs). All program participants receive the same payment amounts for given BMPs.

2.3. Mixed Policy: One-Time and Annual Payments

In this kind of policy scenario, practices will be remunerated via one-time or annual payments, according to whether they generate high initial investments or recurring expenditures. BMPs are classified according to their environmental effectiveness (costs/EG&S obtained), and the most effective practices will be the first to be prescribed and applied. Practices will be added to the policy's portfolio until environmental objectives are reached.

2.4. The "Auction" System

An auction is a market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from market participants. When specifically applied to obtaining EG&S in agriculture, an auction system operates as follows: producers participating in the program propose the amount of money that they would like to receive for implementing a BMP, and only the best proposals in terms of cost per environmental benefit obtained are selected until the target environmental objectives are achieved.



This description implies that the target environmental objectives and their related BMPs are clearly defined. The proposals made by the producers must be analyzed and classified using environmental benefit indicators (EBIs) of varying complexity adapted to the specific characteristics of each case. These indicators express the relationship between the environmental benefit obtained (less phosphorus in water or habitat creation/preservation) and the price of a given proposal.

With auction systems, it is possible to respond to the information challenges that exist in designing agri-environmental policies. Although government decision-makers are more knowledgeable about how BMPs help achieve EG&S, they do not know the actual cost of applying these practices; in contrast, farmers are more knowledgeable about the actual cost of applying practices but do not know how such practices impact the environment. Through auctions, decision-makers inform producers about the environmental impacts of BMPs, while farmers, through their proposals, reveal the cost of implementing the practices to decision-makers.

Auctions reduce private costs because the competition for funds causes participating producers to propose prices as close as possible to their actual costs instead of trying to get as big a payment as possible. This system also enables governments to reach a greater number of farmers systematically and to establish agreements collectively.

2.5. Effluent Trading Schemes

Initially developed and applied with respect to air pollution in the United States, such schemes have flourished in the water quality improvement field. For this study, we will consider measures to improve water quality by reducing phosphorus-containing effluent from agricultural operations.

The effluent trading process is based on the fact that the costs of reducing pollution to a given target level are not uniform between system participants. Different pollution sources have different reduction costs, which is the basis for the motivation to trade. In fact, sources with high pollution control costs prefer to buy reductions or effluent permits from lower-cost sources rather than reducing their own effluent. Moreover, sources that had low reduction costs have an incentive to lower their effluent more than their permit requires, since they can then sell their effluent rights at a higher price than their reduction costs. Society thus wins overall because market forces achieve a given environmental objective by reducing effluent where this can be done at the lowest cost.

Despite the difficulties associated with implementing such programs (e.g., uncertainty of the effluent reductions associated with BMPs), their value is constantly growing because of several highly attractive characteristics:

1. This type of instrument is specific and can be adapted to individual situations – it is a decentralized system;
2. The approach is based on innovative procedures;
3. The participation of farmers and their local associations is a fundamental component – these are voluntary systems.

All things considered, the establishment of such systems is justified because of the major environmental challenges society is facing. In fact, this can be achieved where a formal target has been articulated for a particular watershed, and receptivity combined with government will exists at the national level to provide legal, institutional and financial support to such initiatives (pilot projects, etc.).

This study models a "cap and trade" system, which is based on the government's establishment of an absolute upper limit for all sources covered by the program. This limit is based on the target environmental objective. Permission to emit or discharge is then given to the participating sources, with the maximum value of the total number of permits corresponding to this upper limit. These permits can then be traded among participants. Permit trading allows each source to adopt a strategy specific to its particular circumstances and based on the relative costs of the basic option of either introducing practices or technologies to reduce effluent or purchasing permits from another program participant. As a result, the participants with the lowest effluent reduction costs ensure achievement of the target level. Such programs are thus more effective and reduce the total cost of achieving a defined environmental objective. Since the level of pollution is set by an absolute threshold (cap), this is also called a "closed" system.

Complete details on the choice and definitions of policy options are given in *Cost-Efficiency Analysis of Environmental Goods and Services Policy Options - Technical Report*, Section 2.

3. Choice of Priority Watersheds

3.1. Objectives and Selection Criteria

In order to compare the costs and benefits of various policies that promote the production of EG&S and to identify the ones that can achieve the target EG&S level at the lowest cost, our analysis began with the situation in a representative watershed chosen by pre-established evaluation criteria.

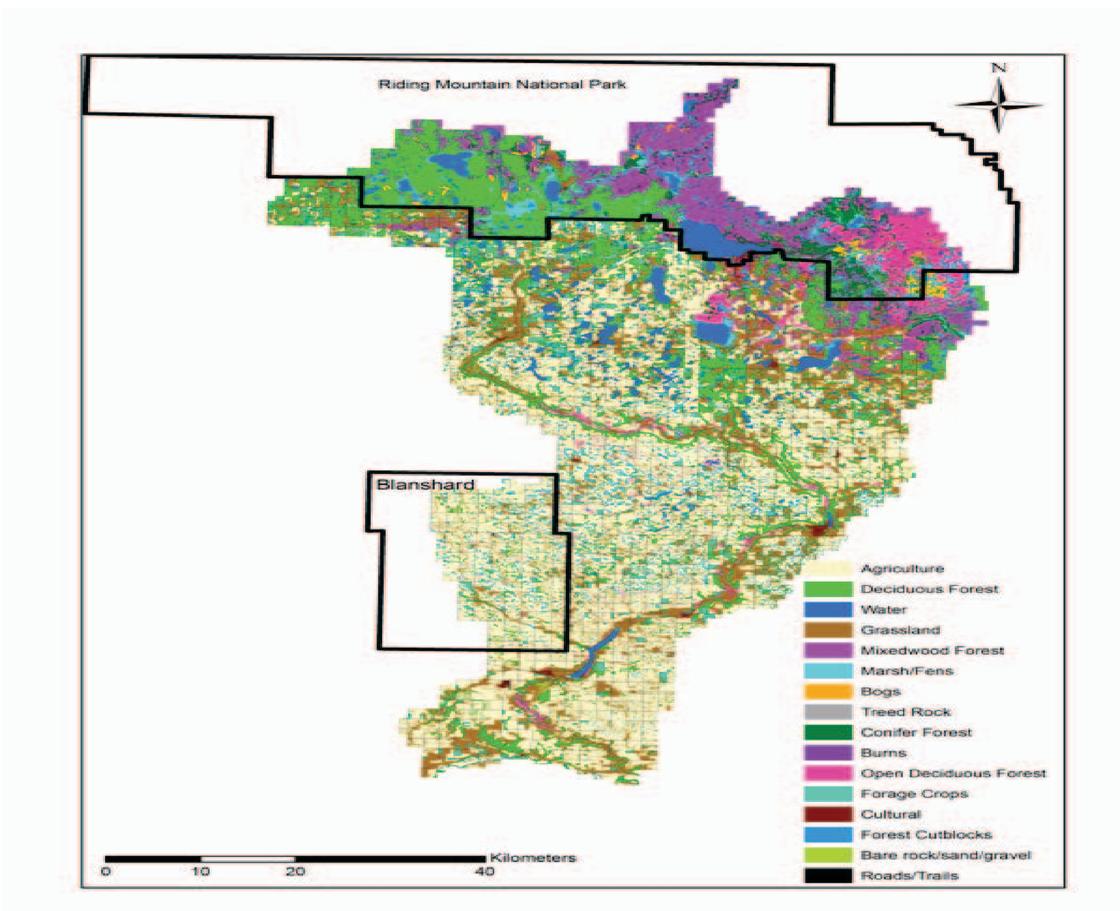
These criteria cover:

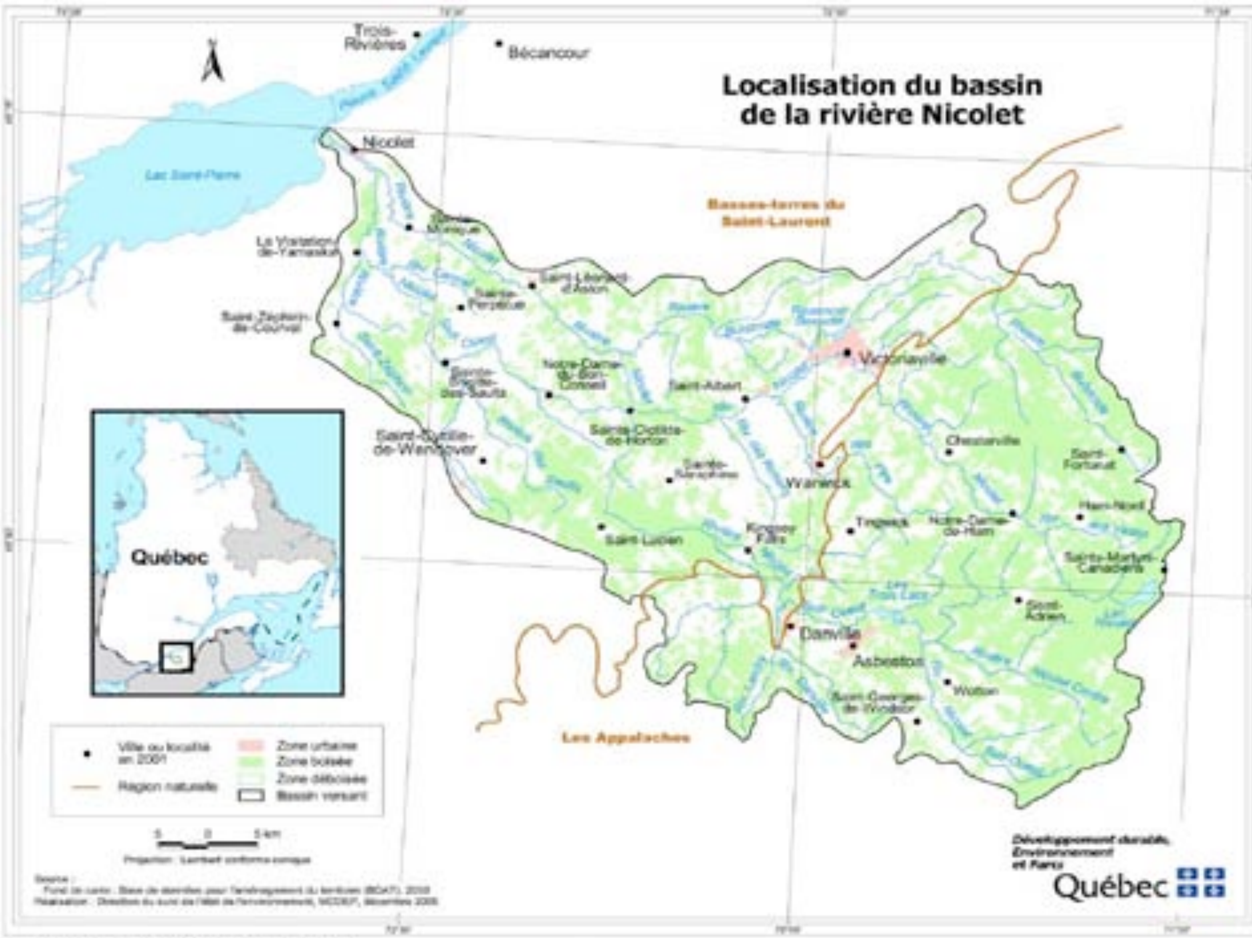
- Watershed's geographic location;
- Only watersheds in major farming regions were considered;
- Watershed size;
- Watersheds less than 1,500 km2 were not considered;
- Watershed's agricultural value;
- More than 30% of the chosen watersheds should be suitable for cultivation;
- Diversity of agricultural practices;
- Shown by the watershed's animal density;
- Presence of agriculture-related environmental problems;

- To produce ecological goods and services, the chosen watershed has to have agriculture-related environmental problems; and
- Available data.
- These criteria are essential if we want to produce an accurate picture and plausible analysis of the territory.

The analysis determined that the two representative watersheds would be the **Little Saskatchewan River watershed in Manitoba** (Western Canada) and the **Nicolet sub-watershed in Quebec** (Central and Eastern Canada).

LITTLE SASKATCHEWAN WATERSHED





Direction du suivi de l'état de l'environnement, MDDEP, décembre 2005.

Details on the choice of representative watersheds are given *Cost-Efficiency Analysis of Environmental Goods and Services Policy Options - Technical Report*, Section 1.1.

4. CHOICE OF PRIORITY EG&S

This section identifies a wide range of EG&S and identifies two for use in this study: water quality from lower phosphorus and wildlife habitat.

The table below presents an extensive list of EG&S cited in the literature by various writers. This list includes 27 EG&S categorized according to the ecosystem functions they support. A glance reveals that some EG&S, including crop pollination and climate control, garner unanimous support, while others, such as ecosystem resistance to invasive species, are cited by only one or two writers.

		Daily (1997)	Costanza et al. (1997)	ESA	ESP	EcoValue Project	De Groot et al. (2002)	Firth (2004)
	Regulation Functions							
1	Purification of air	x		x			x	x
2	Climate regulation	x	x	x	x	x	x	x
3	Regulation of atmospheric chemistry		x			x	x	x
4	Protection from the sun's harmful UV radiation	x		x			x	x
5	Regulation of river flows and groundwater levels	x	x	x	x	x	x	x
6	Water supply		x			x	x	
7	Purification of water	x		x	x		(1)	x
8	Regulation of oceanic chemistry							x
9	Soil formation	x	x	x		x	x	
10	Renewal of soil fertility	x		x	x		x	x
11	Erosion control		x	x	x	x	x	x
12	Nutrient regulations and storage	x	x	x		x	x	x
13	Dispersal of seeds	x		x				
14	Waste absorption and breakdown	x	x	x	x	x	x	x
15	Disease control (Regulate disease carrying organisms)			x			x	x
16	Pollination of crops and natural vegetation	x	x	x	x	x	x	x
17	Ecosystem resistance to invasive species							x
18	Biological control of pests and pathogens	x	x	x	x		x	x
	Habitat Functions							
19	Provision of shade and shelter				x			
20	Provision of habitat for various organisms		x		x	x	x	
	Production Functions							
21	Production of food, fiber, turf, and fuel		x				x	x
22	Maintenance of biodiversity and generic resources	x	x	x	x		x	x
23	Medicinal resources						x	
24	Ornamental resources						x	
	Information Functions							
25	Aesthetic and spiritual amenities	x			x	x	x	
26	Recreation		x			x	x	
27	Support of diverse human cultures	x	x		x		x	

(1) De Groot et al.'s (2002) water supply function includes provision of water for consumptive use, which may cover the water purification function.

*Table format adapted from De. Groot et al.'s (2002) function-based taxonomy.

Based on the table, we are able to identify the EG&S likeliest to be influenced by agri-environmental measures. These EG&S are listed for different components of the natural and social environment. It is clear that beneficial management practices directly or indirectly generate a substantial number of EG&S. It thus becomes necessary to identify the EG&S that will be priorities for achieving the objectives of this study. Therefore, eliminating the EG&S seen as non-priority leaves us with the following EG&S as the focus of our analysis:

- Conservation/restoration of physical water quality;
- Conservation/restoration of biochemical water quality;
- Conservation/restoration of moisture balance;
- Conservation/restoration of biodiversity in wetlands and aquatic environments;
- Habitat creation;
- Conservation/restoration of recreational environments;
- Landscape protection.

Clearly, the EG&S listed above are associated with various types of social uses. Relatively readily quantifiable, significantly influenced by the introduction of BMPs and perceptible by the public, these EG&S are seen as priorities for our analytical purpose.

The priority EG&S identified are quantifiable at the biophysical level; the biophysical change is significant and is publicly perceivable. In the absence of data on all prioritized EG&S, we have chosen biochemical water quality and habitat creation. Biochemical water quality will be evaluated by the total phosphorus (TP) concentration (in mg/L) and habitat creation by wetland and woodland areas (in hectares). The table below summarizes these choices.

Priority EG&S chosen for this study	Parameter
Conservation/restoration of biochemical water quality	- Phosphorus concentration in water
Habitat creation	- Wetland areas - Woodland areas

4.1. Phosphorus Concentration in Water

Total phosphorus in surface water has long been seen as a good indicator of nutrient enrichment in these environments. Only a small portion of the phosphorus in soil is absorbed by plants and other organisms. Another portion is taken to waterways by runoff. Though part of a natural cycle, phosphorus is now in surplus in a number of worldwide aquatic environments, causing numerous surface-water eutrophication problems (algae blooms, massive aquatic plant growth, oxygen deficit, bad odours, fish mortality, etc.). In Quebec, agricultural activity is often cited as the main cause of exceeding environmental criteria for phosphorus concentration in water, while in western Canada, Lake Winnipeg water-quality concerns signal the presence of a similar problem.

In analyzing policies for the effective use of certain BMPs to improve the general condition of the environment and ecosystems, the use of this parameter (total phosphorus concentration in water) will very likely favour longer-term policies. As this element is heavily stored in soils, reductions cannot be measured and reported in the shorter term. Moreover, reducing phosphorus in water may potentially have indirect beneficial effects on other water-quality parameters like cloudiness and suspended solids.

4.2. Wetland Areas

Wetlands (marshes, swamps, seasonal ponds and peat bogs) attract a variety of wildlife. Wetlands are inhabited by various rare or threatened species. Their diversity of plant life, extent and depth make them indicators of environmental quality. According to Environment Canada, their degradation and disappearance entail ecosystem losses and a negative impact on humans with whom they are closely linked. Indeed, wetlands play a role no other ecosystem can fill in terms of natural water-filtration capacity. By absorbing surplus nutrients and pollutants, wetlands not only improve water quality but also play a role in the recycling process for nutrients like nitrogen and phosphorus.

Wetlands also offer numerous socio-economic benefits inasmuch as they can bring economic spin-offs for adjacent communities through ecotourism. Wetlands are also of great interest for scientific research. Our use of this parameter in analyzing policies for the effective use of certain BMPs will promote economic development and the conservation of environmental biodiversity.

4.3. Woodland Areas

A number of ecological goods and services are associated with forests. They provide habitat for a number of species of flora and fauna, including some that are rare or threatened. This makes them essential for maintaining biological diversity. In the agri-environment, they can act as windbreaks to reduce wind erosion of soil. They also reduce surface runoff and the water erosion of soil, which improves water quality by reducing fertilizer and suspended-solid loadings. Furthermore, forests greatly assist groundwater replenishment.

Woodlands also play a socio-economic role by contributing to scenery quality and supporting tourism.

5. TARGET AND CURRENT LEVELS OF PRIORITY EG&S

The analysis acts on the assumption that, given the similarities in provincial agri-environments, in the resulting environmental problems and in BMPs that can be introduced there, the environmental objectives defined in Quebec’s programs and policies are typical of the ones to be achieved across Central and Eastern Canada. Those defined in Manitoba’s programs and policies are typical of the ones to be achieved across Western Canada.

The target levels for priority EG&S are derived from official environmental criteria. These include policies the Quebec and Manitoba governments have already adopted or Environment Canada guidelines regarding the minimum areas of habitat in a watershed.

	Nicolet (East) – Quebec (Eastern and Central Canada)	**Little Saskatchewan River – Manitoba (Western Canada)**
Water quality		
→ Phosphorus	◦ Target level: 0.036 mg/l (share of agriculture from the general target of 0.03 mg/l) ◦ Baseline: 0.041 mg/l (level of phosphorus at 85% uptake of regulated BMPs) ◦ Current level: 0.052 mg/l	◦ Target level: 0.05 mg TP/L ◦ Baseline/Current level: 0.20 mg TP/L
Wildlife habitat quality		
→ Wetland areas	◦ Maintaining existing wetlands ◦ Expanding the area of wetlands by reducing cropping on floodplains	◦ Expanding the area of wetlands
→ Woodland areas	◦ Maintaining existing woodlands	◦ Expanding the area of woodlands

Details on the priority levels of EG&S are given in *Cost-Efficiency Analysis of Environmental Goods and Services Policy Options - Technical Report*, Section 1.3.

6. CHOICE OF BENEFICIAL MANAGEMENT PRACTICES (BMPS)

This section identifies and briefly describes all BMPs chosen to achieve the target levels of EG&S. The following table summarizes the various BMPs chosen in the two case studies.

	Water quality (phosphorus)	Habitat (wetland and woodland)	
		Wetlands	Woodland
Nicolet (East) (Quebec)	• Riparian buffer zones (wooded and grassy, 10 m) • Winter cover crops (for cereals and corn) • Conservation tillage (no-till and reduced till)	• Removing lands prone to flooding from production • Conservation of existing wetlands in agricultural zones	• Conservation of existing forests in agricultural zones
Little Saskatchewan River (Manitoba)	• Wooded riparian buffer zones (10 m) • Converting marginal farmland to wetlands • Winter cover crops • Conservation tillage (no-till) • Manure storage	• Converting marginal farmland to wetlands	• Wooded riparian buffer zones (10 m)

- Water Quality (phosphorus)

The choice of suitable BMPs for achieving target EG&S levels was first conditioned by the availability of information on the effectiveness of each practice, especially for phosphorus. Of the existing coefficients of effectiveness in the literature, we settled on those of the South Nation Conservation Authority (2003) for their reduced information requirements and their ease of use. The South Nation coefficients allowed us to evaluate the impact of each BMP on a relatively equitable basis as they are established on the basis of a consensus of several experts from Ontario and a comprehensive review of BMP literature. These coefficients are used under the Total Phosphorus Management program pilot experience of the Ontario Ministry of Environment on water quality trading in the South-Nation watershed.

Closer to the Canadian Prairies, BMP efficiency rates have also been applied by the Idaho Soil Conservation Commission (ISCC) for a water quality trading program in the Lower Boise Watershed (ISCC, 2002). The efficiency rates do not differ significantly from those of South Nation Conservation.

Each BMP related to phosphorus and chosen for this study is briefly presented in the following paragraphs.

- Manure Storage

Though different storage modes (solid, semi-solid or liquid) affect the amounts of plant nutrients preserved in manure management, this beneficial management practice is heavily influenced by the spreading method and its timing and soil incorporation time. An ideal storage system should prevent nutrient loss during storage and provide enough capacity until the field is safely covered, and spreading should be done in a way that reduces nutrient runoff into ground and surface water.

- Riparian Buffer Zones

Riparian buffer zones play an important role, not only in protecting water and habitat quality, but also in regularizing water flows and stabilizing banks. The term "zone" can denote various arrangements bordering bodies of water, such as areas exclusively composed of forage species or more varied vegetation with forage, bushes and trees. As a rule, species have to be suitable, hardy and non-invasive. In some cases, species sown in riparian zones may represent a source of income for the farmers.

- Conservation Tillage (Reduced Till and No-till)

Conservation tillage is a beneficial management practice that leaves at least 30% of the soil surface covered by residues (stems, leaves, straw from the previous harvest) after seeding. This practice is divided into two major stages:

- a primary stage in which the soil is broken up or lifted instead of turned over; and
- a secondary stage in which the seed bed is prepared, the soil surface levelled (with one or two passes with an implement), and fertilizers and herbicides are incorporated.

This practice helps water quality in a number of ways, including by limiting water and wind erosion through better coverage and increased organic matter in the soil. Conservation tillage has various non-environmental advantages such as time savings in soil preparation. However, we must realize that the success of this BMP depends on the effective control of crops, weeds and residues.

- Cover Crops

Generally speaking, cover crops are put in to offer protection in periods when commercial crops cannot be grown. These cover plants help to limit erosion and runoff. They reduce the amount of soil and nutrients moving toward surface waters. This practice's other advantages include organic soil enrichment and improved soil structure.

- Converting Marginal Farmland to Wetlands

This practice involves transforming less productive agricultural land to wetlands so they can serve as habitats for various wildlife species while at the same time decreasing the level of phosphorus that leaches into rivers.

- Habitat

In the case of habitat, the choice of BMPS is straightforward in both watersheds. For the Nicolet (East) sub-watershed the proposed BMPs are (1) removing lands prone to flooding from production, (2) conservation of existing wetlands and (3) conservation of existing forests. For the Little Saskatchewan River, they are (1) converting marginal farmland to wetlands and (2) the implementation of wooded riparian buffer zones.

Each BMP related to habitat and chosen for this study is briefly presented in the following paragraphs, except for those that are already presented in the water quality section.

- Conservation of Existing Wetlands and Forests in Agricultural Zones

Mainly because they are so fertile, various wetlands and woodlands are cleared and planted every year. Generally speaking, this BMP would involve preserving wetlands and forests in farming areas, since these environments are all crucial for wildlife.

This type of intervention is new to agricultural environmental protection. Manitoba's Alternate Land Use Services (ALUS) project is certainly the most developed program of this kind in Canada at this time. On a case by case basis, it offers farmers compensation by the hectare for preserving a range of natural environments in agricultural districts. For wetlands, the level of compensation varies to reflect use, for example, if no agriculture is practised, if forage is harvested, or if livestock are pastured there. The BMP we used for our analysis is based on the first of these options: the conservation of wetlands and woodlands so that they remain in the wild state.

- Removing Lands Prone to Flooding from Production

This practice involves restoring agricultural floodplains to their natural state so they can serve as habitats for various wildlife species. Like the conservation of wetlands and woodlands, the future generalization of this practice will basically be limited to the existing areas in the watersheds.

Details on the choice of BMPs are given in the *Cost-Efficiency Analysis of Environmental Goods and Services Policy Options - Technical Report*, Section 1.4.

7. BMP Adoption Rates Needed to Attain Environmental Targets

This section briefly reviews the practices that are chosen for each policy, the adoption rates of these practices and the environmental improvements that are achieved.

The selection of BMPs for each policy is based on several principles that are briefly summarized below. Each BMP portfolio reaches the water quality and habitat targets.

For one-time payments, we consider only BMPs that do not involve annual costs, except for opportunity costs. When annual costs are involved, annual payments are automatically used because otherwise producers would have a strong incentive not to respect their obligations while at the same time keeping the one-time payment they already received. Thus, for the Nicolet (East), one-time payments are used for grassed riparian buffers because no annual maintenance is needed, while annual payments are considered appropriate for wooded riparian buffer zones because they involve important annual maintenance. Using the same principle, cover crops should be financed via one-time payments because annual costs of seeding and ploughing are marginal. On the other hand, because the agricultural soils of the Nicolet are considered rich in minerals, producers don't perceive the benefits of this practice and thus do not adopt it even if annual costs are minimal. To help them bypass this barrier, annual payments that cover their annual costs are also considered for this practice, along with an initial payment for technical assistance.

The selection of BMPs for the mixed one-time/annual payments is based respectively on their cost per kilogram of phosphorus eliminated and on their cost per ha of habitat preserved. Thus, the most efficient BMPs in terms of $ per unit of environmental benefit are chosen until environmental targets are reached. The others are eliminated.

For market-based instruments, BMPs are also selected based on their cost per unit of environmental benefit, but here we consider that producers receive their real cost and not the average one estimated within the incentive program. Thus, adoption rates are different from those found in the mixed policy, even if the BMPs happen to be identical.

Target adoption rates for phosphorus BMPs are chosen on the basis of two factors: (1) some realistic levels we obtained after consulting agronomists from the respective regions and (2) the constraint of achieving the phosphorus target. While the realistic level is respected when enough choice of BMPs is available, we exceed it when no other BMPs are available to achieve the phosphorus target for that policy. This is the case of wooded riparian buffers on the Nicolet (East) watershed. Even if a 60% adoption rate is considered quite realistic for this region, we use 80% because both other available BMPs reach or even exceed their realistic adoption level (80% for cover crops and 20% for intercropping or cover crops for corn).

BMP PORTFOLIOS BY POLICY FOR THE NICOLET (EAST) WATERSHED

	Target adoption rates					Water quality target	Habitat target
	One-time payments	Annual payments	Mixed one-time/ annual payments	Auctions	Tradable permits		
Wooded riparian buffers	-	80%	-	-	-	0.036 mg TP/L	-
Grassy riparian buffers	60%	-	60%	50%	50%		
Cover crops for cereals	40%	80%	40%	94%	94%		
Intercropping	-	20%	-	-	-		
Reduced tillage and no-till	70%	-	70%	12%	12%		

Woodland preservation	3%	3%	3%	4.23%	-	-	1,165 ha (825 ha of woodland, 310 ha of wetlands & 30 ha of floodplains) or (1,165 ha of woodland)
Wetland preservation	80%	80%	80%	-	-		
Removing lands prone to flooding from production	80%	80%	80%	-	-		

BMP PORTFOLIOS BY POLICY FOR THE LITTLE SASKATCHEWAN WATERSHED

	Target adoption rates					Water quality target	Habitat target
	One-time payments	Annual payments	Mixed one-time/ annual p.	Auctions	Tradable permits		One-time & annual payments
Cover crops for cereals	-	8%	-	1.8%	1.8%	0.050 mg TP/L	-
Manure storage	5%	-	6.03%	0.01%	0.01%		
Converting marginal farmland to wetlands	3%	3%	-	-	-		550 ha (of wetlands or terrestrial habitat)
Wooded riparian buffers	-	80%	-	-	-		
Grassy riparian buffers	80%	-	100%	100%	100%		

It is important to mention that both environmental objectives remain constant across policies in both watersheds: 0.036 mg TP/L and 1,165 ha of habitat for Nicolet (East) and respectively 0.05 mg TP/L and 550 ha of habitat for the Little Saskatchewan River. On the other hand, because the habitat objective varies in terms of its composition on both watersheds (e.g., 550 ha of wetlands for one-time and annual payments and 550 ha of terrestrial habitat for the other policies in the Little Saskatchewan case), the associated monetary benefits also vary.

The methodology used to estimate the level of BMP adoption needed to achieve the EG&S targets is described in *Cost-Efficiency Analysis of Environmental Goods and Services Policy Options - Technical Report*, Section 1.5 and Section 2.

8. PUBLIC COSTS OF POLICY IMPLEMENTATION

The following table summarizes the payments needed to implement BMPs to reach EG&S targets for each of the five policies examined.

TOTAL PAYMENTS OF DIFFERENT POLICIES IN THE NICOLET (EAST) AND THE LITTLE SASKATCHEWAN WATERSHEDS

	Total payments of different policies in the Nicolet (East) watershed (Million $)	**Total payments of different policies in the Little Saskatchewan River (Million $)**
One-time payments	1.75	2.55
Annual payments	4.2	6.71
Mixed one-time/annual payments	1.68	0.60
Auctions	1.06	0.35
Tradable permits (for P only in Nicolet)	0.55	0.32

Source: ÉcoRessources Consultants computations.

It is clear that the payment levels for market-based policies (auctions and tradable permits) are lower than payment levels for direct payments policies. The methodology used to estimate these costs is given in *Cost-Efficiency Analysis of Environmental Goods and Services Policy Options - Technical Report*, Section 3.2.1.

The public transaction costs of administering these options are given in the following table as a share of program payments. As a share of payments, one-time payments are the least expensive, while tradable permit systems are the most expensive to deliver.

PUBLIC TRANSACTION COSTS OF THE VARIOUS POLICIES

Policy	Public transaction costs (% disbursements) (Nicolet)	Public transaction costs (% disbursements) (Little Saskatchewan River)
One-time payments	9.4	9.4
Annual payments	11.1	11.1
Mixed one-time/annual payments	11.1	11.1
Auction system	11.9	11.9
Tradable permit system	13.8	26

The methodology used to estimate these costs is found in *Cost-Efficiency Analysis of Environmental Goods and Services Policy Options - Technical Report*, Section 3.2.2.

9. MONETARY VALUES OF ENVIRONMENTAL TARGETS

This report estimates the monetary value of environmental improvements through the Benefits Transfer method. This method applies econometric results from other similar studies to the specific environmental targets specified in this study. The methodology draws mainly on meta-models developed by Thomassin and Johnston (2008) for surface water quality and Borisova-Kidder (2006) for wetland and terrestrial habitat.

The value of the improvements is based on the willingness-to-pay of residents of the watersheds covered by the studies for improvements in water quality and habitat over the nine-year period of the improvements. Improvements include drinking, fishing and swimming qualities, wildlife viewing and open space for habitat.

The benefit estimates in this study are similar to those of similar studies, such as Olewiler (2004) and Thomassin and Johnston (2008).

For example, improvements in water quality due to meeting the phosphorous targets in this study are valued at about $10 per household per year in the Nicolet (East) watershed and about $19 per household per year in the Little Saskatchewan River watershed. Details on the monetary values of the environmental benefits of the targeted improvements are provided in *Cost-Efficiency Analysis of Environmental Goods and Services Policy Options - Technical Report*, Section 4.

10. BENEFIT-COST ANALYSIS OF THE DIFFERENT POLICIES

In this section, we analyze the relationships that exist between the environmental benefits obtained and the total costs of the policies for the two watersheds in question, Nicolet (East) and the Little-Saskatchewan River.

The following table shows the total cost of the policies in the Nicolet (East) watershed and in the Little Saskatchewan River, as well as the proportion of expenditures required to achieve each environmental benefit: water quality improvement and habitat creation. These estimates combine the program payments and the transaction costs given in the previous section.

The table shows that in both cases, the cost of implementing policies based on government payments is significantly higher than the cost of implementing market-based instrument policies. Annual payments policy costs are more than two times higher than those of one-time payments, eight times higher than those of a policy based on tradable permits in the Nicolet (East) watershed but less than the costs of the same policy in the Little Saskatchewan case.

TOTAL COST OF POLICIES IN THE NICOLET (EAST) AND LITTLE SASKATCHEWAN WATERSHEDS

	One-time payments	**Annual payments**	**Mixed one-time/annual payments**	**Auctions**	**Tradable permits**
Nicolet (East) watershed million $					
Total water costs	1.50	5.25	1.51	0.82	0.62
Total habitat costs	0.67	0.61	0.61	0.37	-
Total costs	**2.17**	**5.85**	**2.11**	**1.19**	**-**
Little Saskatchewan watershed million $					
Total water costs	2.82	7.46	0.68	0.40	0.40
Total habitat costs	0.23	0.29	0.32	0.32	0.32
Total costs*	**2.82**	**7.46**	**0.68**	**0.40**	**0.40**

*In the case of Western Canada, some BMPs that have an impact on water quality also improve the habitat, and there is no BMP specific to habitat that is not taken into account for water quality. This is why total payments equal the payments for water quality improvement.

However, a more detailed analysis shows that efforts required to reach the water quality improvement target are greater than the efforts needed to preserve habitats on both watersheds. Moreover, in the case of an auction-based policy, the one-time payments policy and the mixed policy, around two-thirds of the costs go towards reducing phosphorous in Nicolet (East) watercourses, whereas only one-third is needed to achieve the habitat preservation target. In the case of the annual payments policy, 90% of the costs is used to achieve the target of expected reduction in phosphorous, and only 10% is needed to preserve habitats inside the Nicolet (East) watershed.

The next table shows the relationship between the value of environmental benefits obtained and the total cost of the policies in the Nicolet (East) watershed. From the outset, we see that if we consider the total value of the environmental benefits obtained through the various BMPs, establishing all these policies is justified because in each case, the benefit/cost ratio is well over 1.

RATIO OF ENVIRONMENTAL BENEFITS OBTAINED /TOTAL COSTS IN THE NICOLET (EAST) WATERSHED

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits (for P only)
(G) Benefit/cost ratio - water (A/D)	**1.05**	**0.30**	**1.04**	**1.91**	**2.53**
(H) Benefit/cost ratio - habitat (B/E)	**4.23**	**4.68**	**4.68**	**6.79**	**-**
(I) Benefit/cost ratio – water & habitat (C/F)	**2.03**	**0.75**	**2.08**	**3.43**	**-**

The picture varies, however, according to the type of benefit obtained. Therefore, in terms of water quality improvement, although most of the policies yield net benefits, the annual payment policy presents a situation in which the total benefits represent only 30% of the costs. Therefore, taken separately, the annual payments policy aimed at achieving water quality is not socially profitable.

As for habitat creation — for which the value of benefits is vastly superior to that for water quality improvement — net benefits are achieved with every policy analyzed for this environmental benefit.

In the Nicolet (East) case, market-based instruments have the best results in terms of benefit/cost ratios for each environmental benefit as well as for the two benefits considered together. If we consider both benefits (water quality and habitat creation), the auctions-based policy has the best benefit/cost ratio (3.43), followed by the mixed one-time/annual payment policy (2.08) and the one-time payment policy (2.03). The annual payment policy has the lowest benefit/cost ratio of all policies examined (0.75).

The benefit-cost ratio numbers for the Little Saskatchewan present almost the same outcome as those of Nicolet (East) in the sense that conclusions do not change with respect to the efficiency of the different policies considered. As in the Nicolet (East) case, market-based instruments have the best results in terms of benefit/cost ratios for water quality. If we consider both benefits (water quality and habitat creation), the auctions-based policy has the best benefit/cost ratio (3.85), followed by tradable permits (3.81), mixed payments (2.24) and one-time payments (0.19). The annual payment policy has the lowest benefit/cost ratio of all policies examined (0.07).

Benefit-cost ratios for the Little Saskatchewan River are generally lower than those of Nicolet (East), and this is explained by two factors. First of all, the population of this watershed is much lower than the population of Nicolet (East), generating much lower water quality benefits in spite of the fact that the value per household is higher (because of the higher improvement in water quality). This generates lower benefit-cost ratios for water quality improvement. Only market-based instruments yield net benefits when water quality is the single environmental objective (1.23 and 1.24 respectively). Secondly, because the habitat objective is lower for this watershed, benefit-cost ratios for habitat are also lower but still much higher than 1 for all policies. If we consider both benefits, one-time payments and annual payments are not socially desirable (0.19 and 0.07) because of the impact of low water benefits and high costs.

RATIO OF ENVIRONMENTAL BENEFITS OBTAINED /TOTAL COSTS IN THE LITTLE SASKATCHEWAN WATERSHED

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits (for P only)
ratio					
Benefit-cost ratio - water	0.17	0.07	0.72	1.24	1.23
Benefit-cost ratio - habitat	0.16	0.12	3.27	3.25	3.21
Benefit-cost ratio – water & habitat	0.19	0.07	2.24	3.85	3.81

11. EXTRAPOLATION OF COSTS AND BENEFITS

In order to generalize the conclusions of this study for all of Canada, we extrapolated the total public costs of the policies and the monetary environmental benefits they generate. Precisely, the costs and benefits estimated for the Nicolet (East) watershed are up-scaled at the level of Central and Eastern Canada (Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador) and those for the Little Saskatchewan River at the level of Western Canada (British Columbia, Alberta, Manitoba and Saskatchewan). Because the necessary data for a detailed extrapolation was not entirely available in the short period of time allocated for this exercise, the results must be carefully interpreted.

11.1. Extrapolation of Costs

The total public costs of the policies considered are scaled-up at the level of all agricultural watersheds of the two regions for both water quality and habitat benefits. Ideally, water quality benefits should be extrapolated only at the level of agricultural watersheds that present phosphorus problems, but because this kind of data is not available in time, we use the larger scale of all agricultural watersheds. As a consequence, costs are overestimated.

Basically, we first scale-up the payments that agricultural producers receive for adopting targeted BMPs and afterwards apply the % of public transaction cost to estimate total public costs. For all BMPs, we use a unitary payment per kg of phosphorus together with the South Nation phosphorus coefficient and the total area of cultivated land or manure. Target adoption rates for water quality BMPs remain the same as those used at the watershed level. As a consequence, we implicitly suppose that the target level of phosphorus is achieved at the level of the two regions at these adoption rates. On the other hand, the target for habitat is re-evaluated at the level of the two regions because it is defined in terms of number of hectares.

Several sources of data are used for the scale-up of costs:

1) For water quality BMPs, we use data on crop areas in agricultural watersheds, which are defined as the watersheds that have more than 5% of their area covered by cultivated land. This data is provided by the Agri-Environmental Policy Bureau of Agriculture and Agri-Food Canada.

2) For the manure storage BMP, we use data from the Census of Agriculture 2006 on the number of cattle in Western Canada.

3) For wetland BMPs in Central and Eastern Canada, we use data on the area of wetlands in agricultural watersheds, which is also provided by the Agri-Environmental Policy Bureau of Agriculture and Agri-Food Canada.

4) Finally, for woodland BMPs in Central and Eastern Canada, we use data on the area of forests in agricultural regions of Quebec, compute the percentage of preserved forests on the Nicolet (East) watershed, apply this percentage to the area of forests in Quebec (agricultural regions only) and adjust the area of protected forests for each province as a function of the total area of the province. These computations are necessary because we don't have access in time to data on the area of forests in agricultural watersheds of the two regions.

5) In Central and Eastern Canada, annual payments remain the most expensive ones with a total of $1,334 million. The general ranking does not change either: market-based mechanisms remain the least expensive instruments for achieving environmental targets ($762 million for auctions) followed by mixed one-time/annual payments ($898 million), one-time payments ($898 million) and annual payments. This ranking remains unchanged for Western Canada, as well as for the whole of Canada. In the west, market-based mechanisms are the least expensive ($107 million for tradable permits) followed by mixed one-time/annual payments ($180 million), one-time payments ($4,485 million) and annual payments ($1,175 million).

AGGREGATED PAYMENTS FOR CANADA

Central and Eastern Canada (million $)

	One-time payments	Annual payments	Mixed policy	Auctions	Tradable permits
Water quality	613	1,049	613	418	314
Habitat	285	285	285	343	-
Total	**898**	**1,334**	**898**	**762**	**314**

Western Canada ($ millions)

	One-time payments	Annual payments	Mixed policy	Auctions	Tradable permits
Water quality	485	1,175	180	119	107
Habitat	38	48	54	54	48
Total*	**485**	**1,175**	**180**	**119**	**107**

Canada ($ millions)

Water quality	1,098	2,224	793	537	421
Habitat	323	333	339	397	48
Total	**1,421**	**2,557**	**1,132**	**934**	**469**

*In the case of Western Canada, some BMPs that have an impact on water quality also improve the habitat, and there is no BMP specific to habitat that is not taken into account for water quality. This is why total payments equal the payments for water quality improvement.

Total public costs for all policies and both regions, split by environmental objective (water quality and habitat) are summarized in the table below. These costs show that in both regions and for the whole Canada, the cost of implementing policies based on government payments is significantly higher than the cost of implementing market-based instrument policies. Moreover, efforts required to reach the water quality improvement target are greater than the efforts needed to preserve habitats. These results confirm those obtained at the watershed level.

AGGREGATED TOTAL PUBLIC COSTS FOR CANADA

	One-time payments (million $)		**Annual payments** (million $)		**Mixed one-time/annual payments** (million $)		**Auctions** (million $)		**Tradable permits** (for P only) (million $)	
	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada
Total water costs	677	536	1,166	1,306	687	202	477	136	358	123
Total habitat costs	315	43	317	54	319	61	391	62	-	56
Total costs[2]	**992**	**536**	**1,483**	**1,306**	**1,006**	**202**	**868**	**136**	**358**	**123**
	1,528		**2,789**		**1,208**		**1,004**		**481**	

The following table gives provincial estimates of the total costs of implementing the five policy options.

[2] In the case of Western Canada, some BMPs that have an impact on water quality also improve the habitat, and there is no BMP specific to habitat that is not taken into account for water quality. This is why total payments equal the payments for water quality improvement.

PUBLIC COSTS OF THE DIFFERENT POLICY OPTIONS, BY PROVINCE, FOR BOTH PHOSPHORUS REDUCTION AND HABITAT PROTECTION

Province	*Costs: ($ millions)*				
	1-time payments	Annual payments	Mix: Annual and 1-time payments	Auctions	Tradable permits
Prince Edward Island	19	27	20	14	10
Nova Scotia	18	25	18	13	4
New Brunswick	30	36	30	19	7
Quebec	347	507	352	344	114
Ontario	542	852	549	426	223
Newfoundland and Labrador	36	37	37	52	0
Manitoba	78	192	27	19	17
Saskatchewan	249	636	69	51	46
Alberta	197	454	96	61	55
British Columbia	13	23	10	6	5
Canada	**1 528**	**2 789**	**1 208**	**1 004**	**480**

11.2. Extrapolation of Benefits

The benefits scale-up procedure follows exactly the same steps as the monetary evaluation of benefits at the level of the two watersheds. The majority of variables keep the same values as those used at the watershed level, except for variables representing revenue, number of households, hectares of woodland and wetland preserved and the proportion of wetlands in the province.

In the case of water quality benefits, we consider that all households of a province, not only those living on the watersheds that present phosphorus problems, appreciate the water quality improvement of those watersheds. To compute monetary benefits linked to phosphorus reduction, all data remains identical to the one used at the watershed level, except for the following:

1) The revenue variable is given the value of the median household income before taxes of each province. The data comes from Statistics Canada's 2006 Census of Population (Table 111-0009) and is transformed into 2002 US$.
2) The willingness to pay per household is multiplied by the total number of households of the province (from the 2006 Census of Population).

To compute monetary benefits linked to wetland preservation, all data remains identical to the one used at the watershed level, except for the following:

1) The revenue variable is given the value of the median household income before taxes of each province. The data comes from Statistics Canada's 2006 Census of Population (Table 111-0009) and is transformed into 2003 US$.

2) The variable "Proportion of wetland in the region" receives the value specific to all agricultural watersheds of the province. This data is provided by the Agri-Environmental Policy Bureau of Agriculture and Agri-Food Canada.

3) Finally, to compute the value of the variable "Acres (ln)" (acres of wetland preserved - ln) we compute for each of the two watersheds the percentage of preserved wetland from all wetlands of the watershed, consider this percentage as representative for all provinces of the respective region and apply it to the area of wetlands in agricultural watersheds to obtain the area of wetlands to be preserved at the level of each province. The detailed computations are presented in Appendix 27, after the one-time payments for Central and Eastern Canada.

To compute monetary benefits linked to woodland preservation, all data remains identical to the one used at the watershed level, except for the value of the variable "Acres (ln)" (acres of woodland preserved - ln). As for wetland preservation, (1) we compute for each of the two watersheds the percentage of preserved woodland from all woodlands of the watershed, but because no data is available in time on the area of forests in agricultural watersheds of the two regions, we use this percentage only for the provinces of Quebec and Manitoba respectively to (2) compute the area of preserved woodlands in theses provinces by applying the percentages to Quebec/Manitoba's forests in agricultural regions and (3) adjust the result for the other provinces as a function of their territory compared to Quebec or Manitoba. The detailed computations are presented in Appendix 27 (after the one-time payments for Central and Eastern Canada).

The habitat benefit for Central and Eastern Canada is different for auctions because the composition of this objective is also different. More specifically, the habitat objective is composed of a mix of wetlands and woodlands for one-time payments, annual payments and mixed payments; it only refers to woodlands for auctions. The composition of the habitat benefit for Western Canada also varies by policy: one-time and annual payments refer to wetlands, and all other policies refer to woodlands. While the composition of the habitat objective is different across policies in both regions, the total number of hectares remains constant in order to maintain the same level of habitat preservation.

Water quality benefits are much higher in Central and Eastern Canada ($632 million) than in Western Canada ($273 million). The difference is explained by the total number of households, which is much higher in the east than in the west. Habitat preservation value is even higher in the east ($2,452 million or $3,257 million) than in the west ($17 million or $257 million) because the habitat objective is much higher in the east (1615 ha versus 500 ha), and one unit of habitat is more valued. These results are similar to those obtained at the watershed level.

TABLE 1 : AGGREGATED BENEFITS FOR CENTRAL & EASTERN CANADA AND WESTERN CANADA

	Central & Eastern Canada	Western Canada
	million $	
	For one-time, annual & mixed payments	For one-time & annual payments
Water quality	**632**	**273**
Habitat (wetland)	**404**	**17**
Habitat (woodland)	**2,048**	**-**
Total	**3,086**	**289**
	For auctions	For mixed payments, auctions and tradable permits
Water quality	**632**	**273**
Habitat (woodland)	**3,257**	**257**
Total	**3,890**	**530**
	For tradable permits	-
Water quality	**632**	
Total	**632**	

11.3. Benefit-Cost Analysis of the Different Policies

The conclusions generated by the benefit-cost analysis at the aggregated level of the two regions are very close to those derived from watershed estimations. If we consider the total value of the environmental benefits obtained through the various BMPs, establishing all these policies is justified because in each case, the benefit/cost ratio is well over 1. This result corresponds to the one obtained at the watershed level.

BENEFIT/COST RATIOS FOR CENTRAL AND EASTERN CANADA

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits (for P only)
million $					
(A) Water benefits	633	633	633	633	633
(B) Habitat benefits	2,453	2,453	2,453	3,257	-
(C) Total benefits (A+B)	3,086	3,086	3,086	3,890	-
million $					
(D) Total water costs	677	1,166	687	477	358
(E) Total habitat costs	315	317	319	391	-
(F) Total costs (D+E)	992	1,483	1,006	868	-
(G) Benefit-cost ratio - water (A/D)	**0.93**	**0.54**	**0.92**	**1.33**	**1.77**
(H) Benefit-cost ratio - habitat (B/E)	**7.79**	**7.74**	**7.69**	**8.33**	**-**
(I) Benefit-cost ratio – water & habitat (C/F)	**3.11**	**2.08**	**3.07**	**4.48**	**-**

The picture varies, however, according to the type of benefit obtained. Thus in terms of water quality improvement, only market-based instruments yield net benefits (1.33 for auctions and 1.77 for tradable permits). The benefit-cost ratios for one-time payments, mixed one-time/annual payments and annual payments are less than 1, even very close to 1 for the first two policies (0.93 and 0.92 respectively). Therefore, taken separately, these three policies are not socially profitable when their unique target is water quality improvement. This result is different from the one obtained at the watershed level where only annual payments are not socially desirable. On the other hand, the ratios for one-time and mixed payments only slightly surpass 1 at the watershed level, meaning they are very close to those obtained for Central and Eastern Canada

As for habitat creation — for which the value of benefits is vastly superior to that of water quality improvement — net benefits are achieved with every policy analyzed for this environmental benefit.

The tradable permit policy has the best results in terms of benefit/cost ratios for water quality (1.77). If we consider both benefits (water quality and habitat creation), the auction-based policy has the best benefit/cost ratio (4.48), followed by the one-time payment policy (3.11), mixed policy (3.07) and annual payment policy (2.08) which has the lowest benefit/cost ratio of all policies examined. This ranking is almost identical to the one estimated for Nicolet (East)

As in the Central and Eastern Canada case, market-based instruments have the best results in terms of benefit/cost ratios for water quality, habitat and the two environmental objectives considered together. If we consider both benefits (water quality and habitat creation), the tradable permits policy has the highest benefit/cost ratio (4.33), followed by auctions (3.89), mixed payments (2.62) and one-time payments (0.54). The annual payment policy has the lowest benefit/cost ratio of all policies examined (0.22).

The tradable permit policy has the best results in terms of benefit-cost ratios for water quality (2.23). The value of habitat benefits is vastly superior to that for water quality improvement — net benefits are achieved with every policy analyzed for this environmental benefit. All these results are similar to those estimated for Little Saskatchewan River.

RATIO OF ENVIRONMENTAL BENEFITS OBTAINED /TOTAL COSTS IN WESTERN CANADA

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits
million $					
(A) Water benefits	273	273	273	273	273
(B) Habitat benefits	17	17	257	257	257
(C) Total benefits (A+B)	289	289	530	530	530
million $					
(D) Total water costs	536	1,306	202	136	123
(E) Total habitat costs*	43	54	61	62	56
(F) Total costs (D)	536	1,306	202	136	123
(G) Benefit-cost ratio - water (A/D)	**0.51**	**0.21**	**1.35**	**2.00**	**2.23**
(H) Benefit-cost ratio - habitat (B/E)	**0.39**	**0.31**	**4.23**	**4.16**	**4.62**
(I) Benefit-cost ratio – water & habitat (C/F)	**0.54**	**0.22**	**2.62**	**3.89**	**4.33**

*In the case of Western Canada, some BMPs that have an impact on water quality also improve the habitat, and there is no BMP specific to habitat that is not taken into account for water quality. This is why total payments equal the payments for water quality improvement.

12. CONCLUSIONS

Before we present the results of our study, some background information is needed. Firstly, the design of the policy has an impact on its cost. The set of BMPs selected is the key to the effectiveness of the policy in terms of the ecological goods and services derived relative to their cost. Moreover, certain practices are more cost-effective than others in achieving environmental objectives.

Secondly, the distinction between one-time and annual payment policies is fictitious, because in theory, an annual payment can always be converted into a one-time payment and vice versa. Thus for a given adoption rate, it is not the method of payment that distinguishes the two programs, but rather the set of BMPs selected. In the case of Quebec, for instance, the cost difference between the one-time and annual payment policies reflects the choice of BMPs and their effectiveness, not the effectiveness of either of the two payment policies per se.

More specifically, with respect to the policies, the results obtained are consistent with economic theory and with the literature. Indeed, policies based on market-based instruments (auctions and permit trading systems) are more efficient. Government can get better value than in the case of direct payment policies where there is an asymmetry of information between public policy-makers and producers, who have more information about their preferences, costs and opportunities (knowledge of technology) (Godard, 2008). Furthermore, according to Stoneham et al. (Stoneham et al., 2007), in Australia's experience, market-based instruments (auctions, permit trading systems, etc.) create an economic environment in which agricultural producers are able to make the optimal choice between the production of goods and the creation of ecological goods and services.

However, market-based mechanisms entail higher public transaction costs. Concerning auction, information problems are resolved as policy-makers inform producers of the environmental impacts of BMPs, and through the bids made, producers reveal to policy makers the costs of implementing the practices. Auctions make it possible to reduce costs, because competition for funding leads producers participating in the program to make bids that are as close as possible to their true costs, rather than seeking to maximize the amount received (Eigenraam et al., 2005). However, an increase in public transaction costs can be expected due to the specific needs associated with the implementation of auction systems: development of a specific environmental diagnostic associated with parcels of land or a set of parcels (Australian approach) or the use of environmental benefits indicators (U.S. approach).

Permit trading systems are not universally applicable and require that certain conditions be met before they can be implemented. Tradable permits apply only to contaminants regulated through standards that are the subject of legal authorization. BMPs related to biodiversity (wetlands and forest cover) cannot easily be taken into consideration with a permit trading system. Besides, fewer government resources are needed to achieve the objective than with other policies for a given level of EG&S derived, since part of the payments would come from the private sector (point sources).

Transaction costs are also higher than in the case of direct payment policies, because there is one more intermediary at the watershed level for the issuance of permits. The amortization of system implementation costs must also be taken into account, which is more complex than in the traditional system of subsidies. The implementations costs can be allocated 1) to the institutional and legal adjustments necessary to make the system work 2) to the operational mechanisms needed and 3) to the social acceptability of the system. However, the achievement of the target and, therefore, the benefits, depends on the growth of point sources in a watershed. Thus, a policy likely cannot be based exclusively on the implementation of a permit trading system to achieve a given objective if a specific time line is adopted. It must be integrated with other mechanisms that provide payments for implementing BMPs. It can therefore be designed as a complementary mechanism.

The following conclusions can also be drawn from our analysis:

- The analysis was based on two representative watersheds: the Nicolet (East) sub-watershed in Quebec and the Little Saskatchewan River watershed in Manitoba.

- The desired environmental benefits analyzed in the CBA are: a reduction of phosphorous concentrations to levels close to those of the National Agri-Environmental Standards Initiative (NAESI) and the maintenance or enhancement of wildlife habitats.

- Measurements of the value and cost of ecological services should be treated with caution. The above estimates are very approximate and have a large margin of error. This margin of error is large because of uncertainty at several stages of the estimation process, including the impact of particular BMPs on nutrient levels, the costs to producers of adopting BMPs, the value that residents of a watershed place on environmental improvements and the extrapolation of results from two local areas to provincial and national levels.

- Preliminary results suggest that to achieve the desired environmental benefits for water quality and habitat at a national scale, aggregated total public costs for Canada would be as follows:
  - ⇒ $2.8 billion, if delivered through an annual payment policy;
  - ⇒ $1.5 billion, if delivered through a one-time payment policy;
  - ⇒ $1.2 billion, for an optimal mix of one-time and annual payments;
  - ⇒ $1 billion, if delivered through an auction based policy tool; and
  - ⇒ $480 million, if delivered through a tradable permit policy;

- The benefits of achieving the desired environmental goals could be worth up to $3.9 billion to the Canadian public, in terms of increased income and recreation, reduced cleanup costs, and other benefits.

- Indications suggest that annual acreage payments are generally the least economically efficient of the policy tools examined, although they can be equivalent to one-time payments for certain BMPs (Beneficial Management Practices).

- Although market-based mechanisms entail higher public transaction costs, government can still get better value than in the case of direct payment policies where there is an asymmetry of information between public policy-makers and producers, who have more information about their preferences, costs and opportunities.

- Program design will direct the decisions made by the producer in terms of practices to implement and the environmental benefit obtained. The producer will agree to implement the practice only if their opportunity costs are compensated by the policy.

- The cost of the various policies depends on the BMPs selected, on geographic scale (watershed level), on selection mechanisms (auctions, tradable permits, others), and on the established payment level.

- One of the possible options for reducing the cost of the policies is to provide guidance to producers on the choice of practices to be implemented. More specifically:
  - ⇒ The most effective BMPs should be prescribed first, until the desired environmental objectives are achieved.
  - ⇒ Relative incentives for specific practices should be determined on the basis of their environmental performance.
  - ⇒ In the case of practices contributing to the achievement of several EG&S at one time, a value should be assigned to each desired environmental benefit.

- However, these solutions present several disadvantages:
  - ⇒ Lacking information on problems that are not solved;
  - ⇒ It is a very normative system based on the implementation of one practice to the detriment of another. This could harm technological innovation, because if regulations are very precise, they could make it impossible to achieve the objective by different means. Indeed, technological innovations make it possible to achieve and even exceed environmental goals at lower costs, in particular by some means that are unknown at the very moment of the implementation of the policy.

- Finally, it is important to adapt environmental objectives and BMPs to the existing context (legal, hydrological, agricultural, etc.). Moreover, programs should be directed towards the achievement of environmental objectives at the watershed level.

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Acronyms

AAFC: Agriculture and Agri-Food Canada

BMP: Beneficial Management Practice

EG&S: Environmental Goods and Services

IISD: International Institute for Sustainable Development

IRDA: Institut de recherche et de développement en agroenvironnement

MAPAQ: Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (Quebec)

OECD: Organisation for Economic Co-operation and Development

MDDEP: Ministère du Développement Durable de l'Environnement et des Parcs (Quebec)

INTRODUCTION

Canada's agricultural sector is currently seeking solutions for various problems. The entire sector is facing a number of challenges around issues that affect the role of agriculture in society. From this standpoint, the main agricultural issues occur in the following areas:

- Income crisis among farm producers caused mainly by consumer requirements, foreign competition and the growing severity of agri-food standards, despite agricultural policies and government transfer payments;
- Increase in production costs due mainly to higher energy and fertilizer prices;
- The search for innovative solutions to curb the impacts of modern agriculture on the environment and the countryside, particularly for water-related issues due to risks of contamination by bacteria and blue-green algae;
- New challenges of shared use and conflicts arising from negative third-party effects of agriculture (noises, odours, dust, etc.), mainly from certain farm practices and growing public concern about environmental issues.

In this context, the recognition of the fact that agriculture provides a range of EG&S beyond food production commands interest from the standpoint of repositioning agriculture relative to the rest of society. This approach stems from the concept of agricultural "multifunctionality" that was made official in 1992 as a result of the United Nations Conference on Sustainable Development (MAPAQ, 2005). Six years later, it was adopted by the agriculture ministers from OECD member states (OECD, 2001a). This concept recognizes that "beyond its primary function of supplying food and fibre, agricultural activity can also shape the landscape, provide environmental benefits such as land conservation, the sustainable management of renewable natural resources and the preservation of biodiversity, and contribute to the socio-economic viability of many rural areas" (OECD, 2001a).

The emergence of the concept of multifunctionality in agriculture meant official recognition of the numerous services provided by agriculture, including the production of EG&S. Since farmers are unable to "sell" their EG&S through traditional marketplaces, the concept of multifunctionality means that governments have to induce farmers to produce them for the society that reaps the benefits.

The core objective of this mandate is to compare the costs of various policies supporting the production of EG&S and identify policies that can achieve the target level of EG&S at the lowest cost.

Specifically, this whole project sets out to achieve the following objectives:

- To identify the policies recognized in the literature as having the greatest potential for generating prioritized EG&S;
- To evaluate, for specific EG&S levels, the private and public costs associated with policy options and their consequent BMPs;
- To compare the costs of the policies and to rank the various policies studied from the perspective of a cost-efficiency ratio.

This study covers two separate Canadian regions in order to consider situations that are as representative as possible of Canada as a whole: Manitoba, standing for Western Canada, and Quebec, standing for Central and Eastern Canada. The Winnipeg-based International Institute for Sustainable Development (IISD) analyzes the Western Canada case, while ÉcoRessources, supported by the Institut de recherche et de développement en agroenvironnement (IRDA), undertakes the analysis for the Central and Eastern Region.

The first chapter deals with the choice of priority EG&S and their associated BMP, sets targets and baselines for each EG&S, evaluates the impact of each BMP on the associated EG&S and selects two representative watersheds, one for the western region and the other for the eastern and central region. The second chapter presents the design of the five policies under study (one-time payments, annual payments, a mix of one-time and annual payments, auction and tradable permits) as well as the BMP portfolios associated with each of them. The estimates of benefits and costs are presented in Chapters 3and 4 while the cost-efficiency ratios are presented in Chapter 5. Chapter 6 extrapolates the cost-efficiency analysis to Western Canada and Central and Eastern Canada so that conclusions may be drawn for the entire country.

Note: Due to the variability of primary data, the results coming from this report must be carefully interpreted.

1. CHOICE OF REPRESENTATIVE WATERSHEDS AND PRIORITY EG&S

1.1. Choice of Representative Watersheds

Freshwater management is increasingly focused at the watershed level, not only in Quebec but also in North America and elsewhere in the world (Temple, 2006; Ramin, 2004; Calbick et al., 2004). The United Nations also recognizes the advantage of making management decisions at the watershed level (FAO-UN, 2006). A number of reasons can be adduced to support this approach, but the most telling is that the watershed represents a visual spatial subdivision that facilitates the analysis of EG&S (EG&S) in this project. Many water quality and human health ecosystem problems are best solved at the watershed level.

1.1.1. Central and Eastern Canada (Quebec)

Quebec's hydric network consists of 430 watersheds. Some are small and others more substantial. In 2002, the new Quebec Water Policy brought integrated watershed-based management to 33 systems that were prioritized because of their advanced level of degradation. Starting with these 33 priority watersheds, a given number of evaluation criteria are analysed in order to determine which of these watersheds would be the most representative of Central and Eastern Canada. These criteria include each watershed's location, size and current agricultural land use, as well as availability of data. By process of elimination, we identify the eastern portion of the Nicolet watershed, the Nicolet sub-watershed, as being the most representative. The details of this process are outlined in Appendix 1.

In essence, the Nicolet sub-watershed[3] is identified as the most representative of Quebec's agricultural watersheds firstly because it is situated south of the St. Lawrence River, where farming activities are more significant and diversified. It also does not cross the U.S. border, where Canadian legislation affecting agricultural management practices can not be enforced.

Secondly, this watershed's size is greater than 1,500 km^2 to the mouth the Nicolet River, which was established as the first criterion. With 36.9% of its territory having been identified as cultivable area in 2001, agricultural activity in this same watershed was considered to be sufficiently intensive. Also, based on animal density in the area, the agricultural activity is considered to be diversified in the Nicolet sub-watershed because it is not dominated by animal or plant production but exhibits a degree of partition between these two main agricultural production categories.

[3] Because there is no water quality location upstream the junction of these two rivers, the Nicolet watershed is analysed by Gangbazo (2005a and 2005b) as two separate sub-watersheds, Nicolet and Nicolet Sud-Ouest.

Thirdly, the presence of agriculture-related environmental problems had to be significant but not overly intensive in order for the chosen watershed to be representative. With integrated watershed-based management, environmental problems related to agricultural practices are reflected in the physicochemical properties of waterways, i.e., the watershed's surface water. Therefore, to argue the representativeness of the environmental problems in the watershed for our analysis, we used median phosphorus concentrations as not influenced by extremes and anomalies. In fact, the Nicolet sub-watershed is the most representative because the average surface-water phosphorus concentration of this watershed is identical to the median of the average concentrations in the 33 priority watersheds.

Lastly, regarding availability of data to support our analysis, research has already been published about the environmental state of this watershed. These publications include Ghazal et al. (Ghazal et al., 2006), published by the Corporation pour la promotion de l'environnement de la rivière Nicolet (COPERNIC), as well as publications by other agencies, such as the Union québécoise pour la conservation de la nature (UQCN/Nature Québec) and Ducks Unlimited Canada.

1.1.2. Western Canada (Manitoba)

IISD has considerable familiarity with Manitoba watersheds through recent work, so a case study watershed from Manitoba was selected in order to draw on this experience. The task of selection then became an issue of selecting a watershed representative of the Prairie region. In order to determine the most representative Manitoba watershed, a least mean squares analysis of variance was carried out on the land use patterns of 24 southern Manitoba sub-watersheds (see Table 2). The analysis is carried out on 17 Manitoba Land Initiative land use classifications. This land use data is available as a GIS layer from the Manitoba Land Initiative website (Manitoba Land Initiative, 2007a). The top-ranked watershed (Netley March) is eliminated because it is not an upstream watershed.

TABLE 2 : ROOT MEAN SQUARES OF MANITOBA WATERSHED LAND USE PATTERNS, BASED ON 16 LAND USE CLASSIFICATIONS

Watershed		RMS
1.	Netley Marsh	0.41
2.	Little Saskatchewan River	0.51
3.	Upper Assiniboine / Lake of the Prairies	0.60
4.	Mid Assiniboine / Brandon to Portage	0.61
5.	Rat River	0.62
6.	Lower Souris River	0.66
7.	Mid Assiniboine / Oak River	0.73
8.	Upper Assiniboine / Birdtail River	0.75
9.	Swan River	0.88
10.	Lower Assiniboine / Portage to Forks	0.96
11.	Whitemud River	0.99
12.	Seine River	1.07
13.	Plum River	1.17
14.	Dauphin Lake	1.19
15.	Upper Pembina River	1.41
16.	Souris / Antler River	1.51
17.	Morris River	1.65
18.	Brokenhead River	1.98
19.	Lower Pembina River / Crystal	2.22
20.	La Salle River	2.35
21.	Duck River	2.48
22.	Lonely River	2.69
23.	Roseau River	2.70
24.	Whitemouth River	2.86

The watershed that ranked second-highest for land-use representativeness is the Little Saskatchewan River (see Figure 12 in Appendix 3 for a layout of the Little Saskatchewan River land use and Table 3 for a comparison of Little Saskatchewan River with typical Manitoba watersheds). The Little Saskatchewan River has well-defined watershed boundaries, and while its land use is highly representative of Manitoba watersheds, it has the added benefit of including parts of Riding Mountain National Park, and the Rural Municipality of Blanshard, site of the ALUS pilot project - an annual payment EG&S pilot project for which some cost information can be used (see Figure 12 in Appendix 3 for locations of Riding Mountain National Park and the Rural Municipality of Blanshard).

TABLE 3 : COMPARISON OF LITTLE SASKATCHEWAN RIVER WATERSHED LAND USE WITH MANITOBA WATERSHED AVERAGE

Land Use	Manitoba Watershed Average		Little Saskatchewan River Watershed	
	ha	%	ha	%
Total Area	390,948		438,208	
Agriculture	162,323	41	159,137	36
Deciduous Forest	48,280	11	64,676	15
Water	10,956	3	22,992	5
Grassland	70,641	16	78,999	18
Mixedwood Forest	17,517	4	34,952	8
Marsh	13,557	3	25,874	6
Bogs	6,795	2	2,544	1
Treed Rock	10	0	0	0
Conifer Forest	11,318	4	10,241	2
Burns	1	0	0	0
Open Deciduous Forest	8,153	2	16,230	4
Forage Crops	12,735	3	12,049	3
Cultural	1,806	1	1,092	0
Forest Cutblocks	1,828	1	0	0
Bare rock/sand/gravel	335	0	207	0
Roads/Trails	8,846	2	9,216	2
Fens	0	0	0	0

Source: Manitoba Land Initiative (2007a).

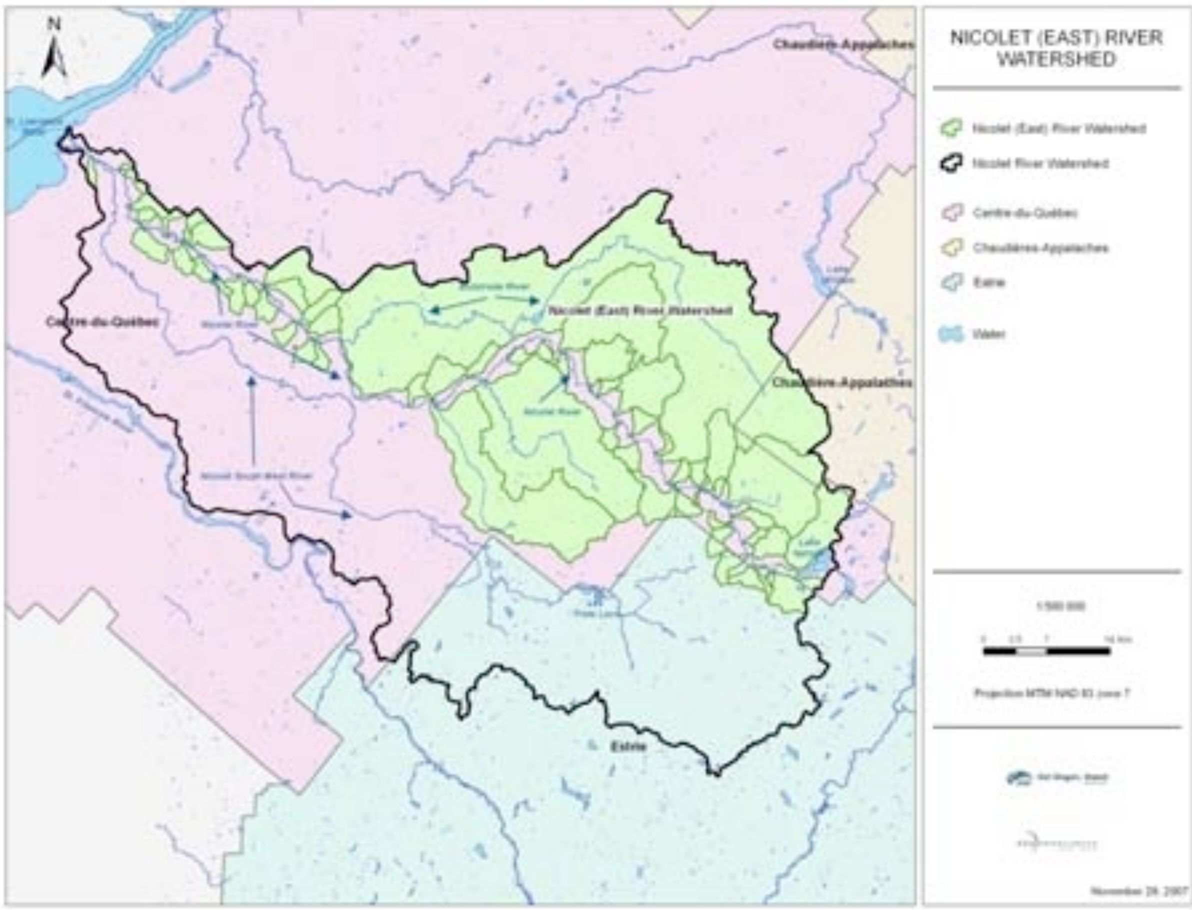
1.2. Description of the Representative Watersheds

1.2.1. Central and Eastern Canada (Quebec)

The Nicolet River Watershed covers a territory of 3,387.8 km2 on the south shore of the St. Lawrence River. This territory is covered by three administrative regions (Centre-du-Québec, Chaudière-Appalaches and Estrie) and is under the jurisdiction of eight county municipalities (RCMs) and 57 local municipalities. Appendix 2 gives a more global description of the Nicolet River watershed.

As shown in Figure 1, the eastern sub-watershed of the Nicolet River is mainly situated in the Centre-du-Québec region, covering a total of 1, 720 km^2 (Gangbazo, 2005a).

FIGURE 1 : NICOLET RIVER SUB-WATERSHED



Source: Del Degan Massé (2008)

In all, there are twenty rivers, twenty-one brooks and seven major lakes and reservoirs in the whole watershed. This categorizes our watershed as poor in these surfaces (Ducks Unlimited Canada, 2006). In fact, free water and wetlands account for only 4.2% of the watershed area (see Table 4). The Nicolet sub-watershed divides into various branches—the Des Rosiers, Des Pins, Nicolet, and Bulstrode —which, after crossing the physiographic complex of the Victoriaville area, run steep gradients that level off abruptly.

The countryside in this watershed is forested in the Appalachian hills, but becomes a heavily farmed landscape in the St. Lawrence lowlands. As demonstrated in Table 4, agriculture occupies almost half the watershed's area in the Centre-du-Québec region, claiming nearly 44.9% of its area.

TABLE 4 : LAND USE ON THE NICOLET WATERSHED

Land Use	Nicolet River Watershed
Agricultural Area	44.9%
Forest Area	45.4%
Anthropogenic area (urban and rural)	4.3%
Lakes and waterways	0.9%
Wetlands	3.3%
Unclassified areas	1.1%

Source: Ducks Unlimited Canada (2006).

Generally speaking, cultivated areas are concentrated down the watershed in the Centre-du-Québec region, while animal units are concentrated between the Pins and Rosiers Rivers in the centre of the watershed. As demonstrated by Table 5, most of the cultivated areas are planted in forage crops (49.5%) and field crops, mainly corn (27.8%).

Table 6, on the other hand, indicates that over 90% of the animal units raised in this region are beef cattle and swine.

TABLE 5 : CULTIVATED AREAS IN THE NICOLET WATERSHED

Production	Area (ha)	Percentage (%)
Total wide-row crops[1] Corn[2]	45,381 33,886	37.2 27.8
Close-row crops[3] Forage[4]	15,398 60,332	12.7 49.5
Other crops[5] Total crops[6]	753 121,864	0.6 100[7]

[1] Sunflowers, tobacco, soya, potatoes, sugar beets, large-scale dry beans, legumes, lentils, silage corn, grain corn, sweet corn, large-scale dry peas.
[2] Silage corn, grain corn, sweet corn (data included in "total wide-row crops").
[3] Mustard seed, flax, mixed grains, barley, buckwheat, rye, triticale, canary grass, oats, wheat, canola.
[4] Alfalfa and mixed alfalfa, artificial or seeded pasture, tame hay and other forage crops.
[5] Fruit trees, other large-scale crops, safflower, turf, forage seeds, nurseries, fruits, small fruits and nuts, greenhouses.
[6] Wide row, close row, forage, other crops.
[7] Addition of wide-row crops, forage and other crops.

Source: Statistics Canada (2001) in Ghazal et al. (2006).

TABLE 6 : ANIMAL UNITS BY PRODUCTION IN THE NICOLET WATERSHED

Production	Animal unit (A.U.)	Percentage (%)
Cattle	81,354	64.3
Swine	34,406	27.2
Poultry	4,901	3.9
Other	5,762	4.6
TOTAL	126,423	100

Source: Statistics Canada (2001) in Ghazal et al. (2006).

Agricultural activity is subject to a number of regulatory requirements in Québec. Appropriate manure storage structures, farm management plans and a minimum riparian buffer strip are examples of these legal obligations. Moreover, a number of voluntary agri-environmental practices have already been adopted by some agricultural producers to curb the negative impact of agricultural activity on local ecosystems. These include various tillage methods, the use of green fertilizers and intercropping, integrated pest management, good water management on farms and fields, crop rotation and buffer zones (Ghazal et al., 2006).

Implementation of 3-metre buffer zones along waterways in the Nicolet River Watershed is still relatively limited (Ghazal et al., 2006). In 2003, 51% of Centre-du-Québec farming enterprises crossed by waterways maintained 3-metre buffer zones, while 92% of these enterprises maintained 1-metre buffer zones (BPR, 2005 in Ghazal et al., 2006).

1.2.2. Western Canada (Manitoba)

The Little Saskatchewan River is a perennial stream running southwards from Riding Mountain National Park to the Assiniboine River west of the city of Brandon. The river meanders over a distance of approximately 200 km (Manitoba Land Initiative, 2007b). The change in elevation over the length of the river is approximately 200 m, with much of the drop occurring in the upper reaches (AAFC, 2004). The watershed of the Little Saskatchewan River is approximately 4,382 km^2 in area, lies in both the black soil and boreal plains ecozones, and is directly adjacent to the Lake Manitoba plain (Manitoba Land Initiative, 2007a; AAFC, 2004). Including the Little Saskatchewan River itself, there are over 700 km of perennially flowing streams, 240 km of indefinite perennial streams, and 900 km of intermittent streams, as classified according to the British Columbia Forest Practices Code by the Manitoba Land Initiative (Manitoba Land Initiative, 2007b). Of these streams, approximately 286 km flow through agricultural land and 256 km are within Riding Mountain National Park. Table 7 details the breakdown of stream types in the watershed,

Figure 13 in Appendix 3 displays the distribution of the stream types and Figure 14 (Appendix 3) shows riparian area land use.

TABLE 7 : STREAM LENGTHS IN THE LITTLE SASKATCHEWAN RIVER WATERSHED, INCLUDING LENGTHS THROUGH AGRICULTURAL LAND AND RIDING MOUNTAIN NATIONAL PARK

Category	Total Length (m)	Total Length through Agricultural Land (m)	Portion in RMNP (m)
CULVERT (Roadway, Railway)	9,034	2,149	283
DITCH	18,229	6,960	0
RIVER /STREAM - CENTRE DOUBLE PEREN	417,838	12,301	58,600
RIVER /STREAM, INDEFINITE	241,486	18,256	69,941
RIVER /STREAM, PEREN (TIME OF PHOTO)	322,532	10,618	74,132
STREAM INTERMITTENT	898,109	235,670	55,703
DAM	60		0

Source: Manitoba Land Initiative (2007a, 2007b).

The northern portion of the watershed in Riding Mountain National Park is dominated by deciduous forest. The southern portion of the watershed is dominated by agriculture (see Figure 12 in Appendix 3). In the 2006 Agricultural Census of Canada (Statistics Canada, 2006), the main agricultural crops reported were wheat, canola, alfalfa, hay, oats and flax (Table 8 summarizes crop distribution in watershed). The watershed is also a livestock-producing area, with cattle being the dominant species (Table 9 lists the major livestock types in the Little Saskatchewan River Watershed).

It is important to note that the area of the watershed in the agricultural land classification of the Manitoba Land Initiative (Manitoba Land Initiative , 2007a), 159,137 ha does not exactly correspond with the area of 183,488 ha reported by Statistics Canada (Statistics Canada, 2007) as being under cultivation. This is likely due to differences between evaluation methods. The Manitoba Land Initiative data is from analysis of digital photography, while the Statistics Canada data is what was reported by farmers. There could be land interpreted as grassland or some other classification from the photographs that may actually be farmland. Moreover, the Manitoba Land Initiative analysis was carried out in 1994 and 2000, while the Statistics Canada information is from 2006, so land previously uncultivated may now register as agricultural land.

Overall, the geography of the Little Saskatchewan River watershed is similar to that of watersheds throughout Western Canada. The rivers rise in hilly highlands that tend to be more forested and less developed for agriculture and descend into larger flatter valleys where agriculture is more concentrated.

TABLE 8 : MAJOR CROPS IN THE LITTLE SASKATCHEWAN RIVER WATERSHED

Crop	ha Seeded	Number of Farms Reporting
Wheat	54,689	340
Canola	40,807	287
Alfalfa and alfalfa mixtures	28,544	407
Hay and field crops	17,092	226
Oats	12,817	228
Flaxseed	9,184	128
Other tame hay and fodder crops	8,230	152
Dry field peas	2,800	35
Total rye	1,220	26
Forage seed harvested as seed	1,199	16
Sunflowers	1,013	7
Mixed grains	794	13
Total corn	604	18
Mustard seed	329	5
Other crops	686	

Source: Statistics Canada (2007).

TABLE 9 : LIVESTOCK POPULATIONS IN LITTLE SASKATCHEWAN RIVER WATERSHED

Animal	Total Herd	Number of Farms Reporting
Bison	316	6
Deer	27	1
Elk	56	3
Goats	439	22
Llamas and alpacas	24	7
Pigs	32,897	23
Sheep and lambs	2,355	26
Cattle and calves	50,518	406
Hens and chickens	96,161	38
Turkeys	469	7
Other poultry	555	8

Source: Statistics Canada (2007).

1.3. Choosing Priority EG&S

According to Agriculture and Agri-Food Canada (AAFC, 2006), "EG&S represent the benefits that human populations derive, directly or indirectly, from the healthy functioning of evolving ecosystems that encompass air, water, soil and biodiversity." Though this definition accommodates farm production as an EG&S and a number of writers have already characterized it as such (De Groot et al., 2002; MAE, 2005), the EG&S concept is used here in its limited meaning as found in MAPAQ (MAPAQ, 2005) or OECD (OECD, 2001a). The EG&S concept in its limited meaning covers only services not integrated by the marketplace, more specifically the economists' "positive externalities." This EG&S concept is derived from the idea of agricultural multifunctionality, which recognizes the services agriculture performs for society beyond food production, such as air or water purification or carbon storage.

Starting from an extended list of EG&S (see Appendix 4), we were able to identify the EG&S likeliest to be influenced by agri-environmental measures prevailing in different components of the natural and social environment. Undoubtedly, BMPs directly or indirectly generate a substantial number of EG&S. It thus becomes necessary to identify the EG&S that will be priorities for monitoring the objectives of this study. In order to do this, the EG&S selected had to be perceptible by the public and had to be related to quantifiable biophysical changes that were non-marginal. Given these selection criteria (see Appendix 4), it was established that our environmental objectives would be monitored mainly by:

- Biochemical water quality and
- Wildlife habitat.

These were therefore identified as our EG&S priorities. In view of the technical, scientific and time constraints we are dealing with in this project, we identified EG&S that can be part of a monitoring campaign and associated with existing data. EG&S for which we have no recognized evaluation process and/or where the information needed to measure change is unavailable or insufficient were immediately eliminated. Though technically feasible, the quantification, compilation and availability of data related to factors associated with other EG&S are what prevented us from analyzing a more extended number of EG&S. The whole process of priority EG&S selection is outlined in Appendix 4.

In view of the fairly short length of this mandate and the absence of data on all prioritized EG&S, we established that biochemical water quality would be evaluated by the total phosphorus (TP) concentration (in mg/L) and habitat creation by wetland and woodland areas (in ha). The table below summarizes these choices.

TABLE 10 : PRIORITY EG&S CHOSEN FOR THIS STUDY AND MEASUREMENT PARAMETERS

Priority EG&S chosen for this study	Parameter
Conservation/restoration of biochemical water quality	- Phosphorus concentration in water
Habitat creation	- Wetland areas - Woodland areas

Total phosphorus in surface water has long been seen as a good indicator of nutrient enrichment in the environment. Only a small portion of the phosphorus in soil is absorbed by plants and other organisms. Another portion is taken to waterways by runoff. Furthermore, in analyzing policies for the effective use of certain BMPs to improve the general condition of the environment and ecosystems, the use of this parameter will very likely favour longer-term policies. As this element is heavily stored in soils, reductions cannot be measured and reported in the shorter term. Moreover, reducing phosphorus in water may potentially have indirect beneficial effects on other water-quality parameters such as cloudiness and suspended solids.

Wetlands are inhabited by various rare or threatened species. Their diversity of plant life, extent and depth make them indicators of environmental quality (Environment Canada, 2006). According to Environment Canada, their degradation and disappearance entail ecosystem losses and a negative impact on humans with whom they are closely linked. Wetlands also offer numerous socio-economic benefits inasmuch as they can bring economic spin-offs for adjacent communities through ecotourism. Wetlands are also of great interest for scientific research. Our use of this parameter in analyzing policies for the effective use of certain BMPs will promote economic development and the conservation of environmental biodiversity.

A number of EG&S are associated with forests. They provide habitat for a number of species of flora and fauna, including some that are rare or threatened. This makes them essential for maintaining biological diversity and is why we chose forest area to monitor the effect of BMPs on the wildlife habitat EG&S.

1.4. Target and Current Levels of Priority EG&S

This section defines target levels for each parameter associated with the priority EG&S identified earlier and presents their current levels associated for the selected watersheds. Our analysis is based on current government regulations and objectives in the regions studied. For comparison purposes, Table 11 summarizes the target levels of each EG&S for both case-study regions. The next two sections present the origin and rationale of these targets.

TABLE 11: TARGET AND CURRENT EG&S LEVELS

	Nicolet – Quebec (Eastern and Central Canada)	**Little Saskatchewan River – Manitoba (Western Canada)**
Water quality		
→ Phosphorus	◦ Target level: 0.036 mg/l (share of agriculture from the general target of 0.03 mg/l) ◦ Baseline: 0.041 mg/l (level of phosphorus at 85% uptake of regulated BMPs) ◦ Current level: 0.052 mg/l	◦ Target level: 0.05 mg TP/L ◦ Baseline/Current level: 0.20 mg TP/L
Wildlife habitat quality		
→ Wetland areas	◦ Maintaining existing wetlands ◦ Expanding the area of wetlands by reducing cropping on floodplains	◦ Expanding the area of wetlands
→ Woodland areas	◦ Maintaining existing woodlands	◦ Expanding the area of woodlands

Our analysis proceeds on the assumption that, given the similarities in provincial agri-environments, in the resulting environmental problems and in BMPs that can be introduced there, the environmental objectives defined in Quebec's programs and policies are typical of the ones to be achieved across Central and Eastern Canada while those defined in Manitoba's programs and policies are typical of the ones to be achieved across Western Canada.

The target levels for priority EG&S are derived from official environmental criteria. These include policies the Quebec and Manitoba governments have already adopted or Environment Canada guidelines regarding the minimum areas of habitat in a watershed.

1.5. Water Quality

Nicolet

The highest total phosphorus concentration needed to curb algae and aquatic plant growth in surface water and prevent eutrophication has been set at 0.03 mg TP/L by Quebec's Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP) in a paper entitled "Surface water-quality criteria in Quebec" (MDDEP, 2007). According to Gangbazo et al. (Gangbazo et al., 2005a), the median total phosphorus concentration in some rivers of Quebec is still two to six times greater than this criterion. However, phosphorus concentrations have dropped in several Quebec watersheds following urban clean-up drives combined with new solid and liquid manure storage structures on farms to deal with point pollution sources.

The target concentration of 0.03 mg/L set by Quebec's MDDEP is a cumulative target for all sources within a watershed. As a consequence, agriculture should contribute to this target in proportion to its contribution to all phosphorus loadings of human origin, which is of 73% for the Nicolet sub-watershed. Thus, the target concentration for agriculture is 0.036 mg/L instead of 0.030 mg/L. All computations that led us to this number are presented in Appendix 5.

Weighted average phosphorus concentration at water-quality monitoring stations on Nicolet between 2001 and 2003 was 0.052 (Gangbazo et al. 2005b). However, because the baseline is considered to be the actual level of regulation and because several BMPs are already regulated in Quebec, we consider that the regulated BMPs are already adopted by 85% of agricultural producers. Based on this hypothesis, we estimate the phosphorus concentration corresponding to the actual level of regulation at 0.041 mg/L (see Appendix 6 for details).

Little Saskatchewan River

Manitoba has identified phosphorous as a major concern in the province's waterways. Phosphorous has been implicated in the eutrophication of Lake Winnipeg and other bodies of water, and measures are being taken to reduce loading. Despite the impetus to reduce phosphorous, no guidelines exist on its concentration in surface waters (Manitoba Conservation, 2002a). The lack of established water quality guidelines for Manitoba made it necessary to look to other jurisdictions for a P target. The Prairie Provinces Water Board (PPWB) is the agency in charge of managing interprovincial water issues for the three Canadian Prairies. The Master Agreement on Apportionment sets out water quantity allocations between upstream and downstream provinces (PPWB, 1969). An annex on water quality was included in

1992, which outlines expected water quality at twelve interprovincial monitoring locations (PPWB, 1992). The maximum total phosphorus concentration at most of these twelve locations is 0.05 mg/L. Since this is an interprovincial agreement that applies in all three Prairie Provinces, it was selected as the water quality target for the western case study.

Published data on nutrient loadings is available from a report on nutrient loading to Manitoba waterways. Data for P loading for the Little Saskatchewan River has been published and documented for 1994, 1995, 1996, 2000 and 2001 (Manitoba Conservation, 2002b). The average P loading for these five years is 29 tonnes per year. These data are based on single yearly samplings and are highly variable. This variability is likely due to the timing of the sampling. Phosphorus concentrations could be higher or lower depending on the time of year the samples were taken, the flow in the river, and whether rainfall events had recently occurred. While the total loading to Lake Winnipeg is of interest, the water quality target from the Prairie Provinces Water Board, which is concentration-based at 0.05 mg/l, is given as a concentration so some calculation was carried out to determine an equivalent average concentration. The average annual flow of the Little Saskatchewan River below Lake Wahtepanah is 4.55 m^3/s (AAFC, 2004), for an average annual flow of 143,488 megalitres. With a total P loading of 29 tonnes, this represents an annual average total phosphorus concentration of 0.20 mg/L. Given that the target level for Western Canada is 0.05 mg/L, this requires a reduction of 0.15 mg/L. Assuming that the average annual flows in the Little Saskatchewan River remain constant, a 75% reduction in P loading will be required. Therefore, the water quality target for the Little Saskatchewan River Watershed is a 75% reduction in P loading, for an average concentration of 0.05 mg/L. The total amount of phosphorus to be reduced is 22 tonnes per year.

1.5.1. Habitat

Because no objectives for wetland and forest areas are presently defined by the provincial governments of Quebec and Manitoba, the federal guidelines for the Great Lakes are used to orient the target levels of habitat. According to these guidelines, wetlands should make up over 10% of watersheds and over 6% of sub-watersheds while forests should cover more than 30% of the watershed area (Environment Canada, 2004). Even if these objectives are precisely fixed for the Great Lakes ecosystem, they are based on a review of studies of several ecosystems. We then use these objectives as guidelines for both watersheds.

Nicolet

Nicolet sub-watershed already meets these guidelines for forests, which cover 45% of its area. The objective is then set to maintaining the existing forests in agricultural zones, where the pressure for deforestation is not negligible. The search for hog manure spreading areas to comply with regulations and the high price of grain corn are two factors that strongly pressure farm producers to increase cultivated areas by deforestation (MENV, 2003).

Quebec's Agricultural Operations Regulation (AOR) generally prohibits farmers from expanding cultivated land in watersheds with excessively high phosphorus levels. However, the AOR does allow a land parcel exchange system whereby, after duly notifying the MDDEP (Quebec Department of Sustainable Development, Environment and Parks), farmers can abandon cultivation on one parcel and then clear others for cropping purposes (AOR, sec. 50.4). Thus, since the AOR allows for deforestation, maintaining woodlands in agricultural areas in Quebec is an eligible target for incentive programs.

The 6% wetland objective specified by Environment Canada (Environment Canada, 2004) guidelines is far from being reached on the Nicolet sub-watershed where wetlands represent only 2.72% of its area. The objective of this study is then set to expand the area of wetlands by reducing cropping on floodplains while maintaining the existing wetlands in agricultural zones, where the pressure for transforming wetlands into cultivated lands is not negligible.

As in the case of woodlands, section 50.4 of Quebec's Agricultural Operations Regulation (AOR) allows farmers to abandon cultivation on one parcel and then drain others for cropping purposes. On the other hand, the Environment Quality Act (section 22) protects wetlands from being drained by requiring authorization for each project, but the process of authorization offers greater protection to the most visible wetlands and leaves the less known ones with a higher risk of disappearance. Thus, since the AOR and the Environment Quality Act still allow for wetlands to be drained, maintaining wetlands in agricultural areas in Quebec is an eligible target for incentive programs.

Little Saskatchewan River

With 28.8% of its area falling under the deciduous, mixedwood, conifer and open-deciduous forest MLS land classifications, the Little Saskatchewan River watershed almost meets the Environment Canada guideline (Environment Canada, 2004) for forests (30%). The objective is then to slightly increase the area of woodlands through the implementation of wooded riparian buffers.

The 10% wetland objective specified by Environment Canada (Environment Canada, 2004) guidelines is not yet reached on the Little Saskatchewan River watershed where 6.5% of the watershed area falls under the marsh or bog MLI classifications. The objective of this study is then set to expand and maintain the wetlands area by reducing cropping on marginal agricultural land.

Land use quantification has been carried out by the Manitoba Land Initiative by determining land use from aerial photographs. GIS layers of these data are available online (Manitoba Land Initiative, 2007a). The land use map presented as Figure 12 in Appendix 3 is assembled from 2000 data, except for the extreme southern portion of the watershed for which only 1994 data is available. This data is being assumed as the baseline amount of habitat for measuring biodiversity. Our biodiversity target for the Little Saskatchewan River Watershed is the enhancement of natural habitat, including wetlands, riparian areas, and woodland.

2. DESIGN OF POLICIES AIMING AT ENHANCING EG&S PRODUCTION AND CHOICE OF THE BMPS ASSOCIATED TO EACH POLICY

This report takes an in-depth look at various types of policies to determine their effectiveness in producing least-cost environmental goods and services. These policies consist of one-time payments, annual payments, a mixed policy of one-time and annual payments as well as market-based instruments in the form of auction mechanisms and emissions trading schemes.

The policy scenarios designed are based on existing agro-environmental programs, such as the federal government's National Farm Stewardship and Greencover Canada programs, the Advancing Canadian Agriculture and Agri-Food Canada (ACAAFC) program, the Alternative Land Use Services (ALUS) pilot project in Manitoba, the Quebec's Farm Income Stabilization Insurance (FISI) and Agri-Environmental Support Plan (PAA in French). We also used some existing programs in other countries such as the U.S.A.'s Conservation Reserve Program (CRP), Australia's BushTender and EcoTender programs and France's agro-environmental measures (AEMs).

The primary purpose of these policies is to encourage adoption of BMPs to achieve target EG&S. Selecting the portfolios of practices that will qualify users for payments is thus a central part of the policy design process, and policy effectiveness will depend on this aspect to a great extent.

The geographical regions where these policies will be applied consist of two representative river watersheds: the Nicolet in Quebec and the Little Saskatchewan River in Manitoba. In the context of this comparative study, it is assumed that the level of BMP adoption and supervision is identical for all policies and for both case studies.

The types of BMPs covered and the reference level set for payments implies compliance with existing regulations. Thus, in Quebec, for example, the province's *Agricultural Operations Regulation* (AOR) currently requires farmers to respect buffer strips three metres wide along watercourses, whereas it is now proposed to expand this buffer zone to grassy strips 10 metres wide, have appropriate manure storage facilities or treat dairy wastewater. Buffer strips of 3 metres are also required under the Protection policy for lakeshores, river banks, littoral zones and floodplains.

Under this system, producers requiring financial assistance must apply for eligibility and provide several supporting documents, such as original invoices and copies, if required, of all cheques issued to and cashed by suppliers. Moreover, penalties are stipulated in case of failure to fulfil contractual obligations. The purpose of these penalties is to reduce public transaction costs, i.e., to mitigate the consequences of such failure. However, these penalties have not been used in calculating the costs engendered by the policies, but primarily serve as a means of encouraging program participants to meet their contractual commitments.

2.1. Policy Design

2.1.1. One-Time Payments

The aim of this policy is to encourage implementation of certain BMPs through one-time payments covering all the net losses incurred by farmers complying with their contractual commitments. Under this policy, producers undertake to implement BMPs on their farms in exchange for one-time financial compensation.

According to economic theory, under identical monitoring conditions, operators are more likely to deviate from contractually obligated behaviour if the entire payment is received at the beginning of the contract period than if it is paid in several instalments and no penalty mechanisms are otherwise involved. We have therefore decided to use the one-time payment mechanism mainly for BMPs that do not entail major annual expenditures, because a one-time payment approach is likely to be less effective for BMPs involving significant annual expenses.

In cases where government in Canada makes one-time payments for practices requiring investment and, in some recent cases (e.g., the Greencover Canada Program[4]), for practices involving annual opportunity costs, the loss of environmental effectiveness is probably offset by the lower costs of such one-time payment programs.[5] For this reason, we have decided to include in the one-time payment policy portfolio the practices of maintaining woodlands and wetlands in agricultural areas and of reducing cropping on agricultural floodplains.

Another factor is the refusal of some producers to implement certain practices that they feel are too complex. One such practice is conservation tillage or direct seeding, which requires a certain expertise. Accordingly, we have decided to take into account the technical support required to implement such practices, which is usually necessary at project start. We will therefore use one-time payments to cover both investments engendering an annual opportunity cost and a certain level of technical support. These costs are then actualized and totalled to determine the value of the one-time payment for each practice.

[4] Under the Greencover Canada Program, the amount to be repaid because of failure to meet contractual commitments and provisions is not considered a penalty, but rather compensation to AAFC for the harm caused by the producer's failure to meet commitments. It is also stipulated that this compensation "*may be set-off against any monies that may be or become payable by Canada and/or any federal Crown corporation to the Eligible Applicant, until paid in full*."
[5] Costs are lower provided that the level of oversight is the same. Otherwise, much more monitoring is required to obtain the same level of success with one-time payments as that achieved with annual payments.

The BMPs that make up our one-time payment policy portfolio are: grassy riparian buffer strips (without maintenance), cover crops for cereals, conservation tillage and direct seeding, maintaining woodlands and wetlands in agricultural areas[6], crop reduction on agricultural floodplains, and manure storage.

The payment level corresponds to a certain percentage of the value of the investments made up to a predetermined limit. In the cases of maintaining woodlands and wetlands in agricultural areas and of crop reduction in agricultural floodplains, the payment level represents the actualized amount of the opportunity cost associated with use of the land. In terms of technical support, the one-time payment corresponds to the cost of technical assistance for two years.

Table 12 shows the main features of our one-time payment policy.

TABLE 12 : FEATURES OF THE ONE-TIME PAYMENT POLICY

One-time payment	Province	
	Quebec	Manitoba
Eligibility	▪ All farmers and for all their land owned or leased ▪ Exception: For certain practices that involve an alternative use (i.e., crop reduction on agricultural floodplains), only landowners are eligible.	
Eligible BMPs	▪ Grassy buffer strips 10 m wide ▪ Cover crops ▪ Conservation tillage (no-till and reduced till) ▪ Conservation of wetlands in agricultural areas ▪ Crop reduction in agricultural floodplains.	▪ Grassy buffer strips 10 m wide ▪ Cover crops ▪ Conservation of woodlands and wetlands in agricultural areas ▪ Manure storage.
Technical support	Yes, for certain BMPs (i.e., cover crops)	
Contract period	▪ Does not apply to investments ▪ Nine years for BMPs that generate payments or recurring shortfalls ▪ Two years for technical support.	
Penalties	Farmers wishing to terminate their contract early and those who fail to meet their contractual commitments will be required to repay the total amount of the grant less an amount corresponding to half the annual opportunity cost (penalty modelled on the ALUS pilot project and the Greencover Canada program).	

[6] In this case, the one-time payment is equivalent to a conservation easement for the contract period.

2.1.2. Annual Payments

The annual payment policy consists of awarding financial compensation to program participants for all the net annual expenses incurred by implementing BMPs on their farms. The portfolio of BMPs qualifying for the annual payment program thus consists of practices that involve recurring expenses, i.e., establishing treed buffer strips[7] (with maintenance), cover crops, intercropping, maintaining woodlands and wetlands in agricultural areas, and crop reduction on agricultural floodplains.

As in the case of one-time payments, all farmers are generally eligible for the program for all their owned or leased land. However, in the case of certain practices requiring an initial investment, only owned land qualifies.

The contract period is for three years and can be renewed twice, i.e., up to a total of nine years. In terms of penalties, producers who do not fulfil their contractual commitments will not receive assistance for the year in question, and producers wishing to terminate their contracts before expiry will be required to repay half the annual amount of the remaining years (penalty modelled on the ALUS pilot project and the Greencover Canada program).

All program participants receive the same payment amounts for applying BMPs. The payment amounts are calculated on the basis of the average farm model used for Quebec's Farm Income Stabilization Insurance program and the calculation methods employed by the Manitoba Agricultural Services Corporation.

Table 13 summarizes the main features of the annual payment policy.

[7] Access to watercourses must be provided to allow maintenance. This maintenance, which generally takes place every 15 to 20 years, can be performed every 30 years if a treed buffer strip is established, because such strips reduce silting in watercourses. In fact, treed buffer strips can be planted on both banks if access is provided to watercourses for maintenance purposes.

TABLE 13 : FEATURES OF THE ANNUAL PAYMENT POLICY

Annual payment	Province	
	Quebec	**Manitoba**
Eligibility	▪ All farmers and all their land owned or leased ▪ Exception: For certain practices that involve an alternative use (i.e., crop reduction on agricultural floodplains), only landowners are eligible.	
Eligible BMPs	▪ Wooded buffer strips 10 m wide ▪ Cover crops ▪ Intercropping ▪ Conservation of wetlands in agricultural areas ▪ Crop reduction in agricultural floodplains.	▪ Wooded buffer strips 10 m wide ▪ Cover crops ▪ Conservation of woodlands and wetlands in agricultural areas
Technical support	Yes, for certain BMPs (i.e., treed riparian buffer strips)	
Contract period	▪ Three years, renewable twice	
Penalties	▪ Farmers who do not meet their contractual commitments are not paid for the year in question. ▪ Farmers wishing to terminate their contracts early will be required to repay half the annual amount of the remaining years (penalty modelled on the ALUS and Greencover Canada programs).	

2.1.3. Mixed Policy : One-Time and Annual Payments

In this kind of policy scenario, practices will be remunerated via one-time or annual payments, according to whether they require high initial investments or recurring expenditures. BMPs are classified according to their environmental effectiveness (costs/BSE obtained) and the most effective practices will be the first to be prescribed and applied. Practices will be added to the policy's portfolio until reaching the environmental objectives.

Table 14 shows the main elements of a mixed policy of one-time and annual payments.

TABLE 14 : FEATURES OF THE MIXED POLICY

Mixed policy	**Province**	
	Quebec	**Manitoba**
Eligibility	▪ All farmers and all their owned or leased land ▪ Exception: For certain practices that involve an alternative use (i.e., crop reduction on agricultural floodplains), only landowners are eligible.	
Eligible BMPs	▪ Wooded buffer strips 10 m wide ▪ Grassy buffer strips 10 m wide ▪ Cover crops ▪ Intercropping ▪ Conservation tillage (no-till and reduced till) ▪ Conservation of wetlands in agricultural areas ▪ Crop reduction in agricultural floodplains.	▪ Wooded buffer strips 10 m wide ▪ Grassy buffer strips 10 m wide ▪ Cover crops ▪ Conservation of woodlands and wetlands in agricultural areas
Technical support	Yes, for certain BMPs (i.e., wooded riparian buffer strips)	
Contract period	▪ Does not apply to investments ▪ Three years, renewable twice for BMPs that generate payments or recurring shortfalls ▪ Two years for technical support.	
Penalties	▪ Farmers who do not meet their contractual commitments are not paid for the year in question. ▪ Farmers wishing to terminate their contracts early will be required to repay half the annual amount of the remaining years (penalty modelled on the ALUS pilot project and the Greencover Canada program).	

2.1.4. The "Auction" System

According to McAfee and McMillian (OCED, 2007b), "*an auction is a market institution with an explicit set of rules determining the resource allocation and prices on the basis of bids from market participants*." When specifically applied to obtaining EG&S in agriculture, an auction system operates as follows: producers participating in the program propose the amount of money that they would like to receive for implementing a BMP, and only the best proposals in terms of environmental benefit obtained per cost are selected until the target environmental objectives are achieved. This system implies the producer's *willingness to accept* compensations for applying BMPs. Therefore, the amount of compensation that individual producers will demand for applying agro-environmental practices are revealed through their bids.

In this system, environmental objectives and their related BMPs must be clearly defined. The proposals made by the producers must be analyzed and classified using not only offer prices but also environmental benefit indicators (EBIs) that are of varying complexity and adapted to the specific characteristics of each case. For every given proposal, the relationship between the environmental benefit obtained (less phosphorus in water or habitat creation/preservation) and the producer price will be analyzed.

With auction systems, it is possible to respond to the information challenges that exist in designing agro-environmental policies. Although government decision-makers are more knowledgeable about how BMPs help achieve EG&S, they do not know the actual cost of applying these practices. In contrast, farmers are more knowledgeable about the actual cost of applying practices, but do not know how such practices impact the environment. Through auctions, decision-makers inform producers about the environmental impacts of BMPs, while farmers, through their proposals, reveal the cost of implementing the practices to decision-makers.

Auctions reduce private costs because the competition for funds causes participating producers to propose prices as near as possible to their actual costs instead of trying to get as big a payment as possible (Eigenraam et al. 2005).[8]

This system also enables governments to reach a greater number of farmers systematically and to establish agreements collectively (Stoneham, 2002).

Establishing an Agro-Environmental Policy Based on an Auction System

The following diagram shows the procedure for setting up an auction system to encourage development of on-farm BMPs.

[8] However, an increase in public transaction costs can be expected, mainly because of the specific requirements associated with establishing auction systems: preparing specific environmental diagnoses for the land parcels or sets of parcels concerned (the Australian approach) or applying EBIs (the approach used in the USA's Conservation Reserve Program).

Identify target BMPs	⇒	Awareness-raising: Perform environmental diagnoses Establish list of BMPs to be implemented	⇒	Farmers: Submit proposals Calculate the value of EBIs	⇒	Select offers on the basis of their cost-effectiveness in achieving the target EG&S (> EBIs/price ratio are chosen first)	⇒	Implement the BMPs	⇒	Obtain the EG&S

The first step consists in determining the target environmental objectives. Next, the "awareness-raising" stage begins with an advertising campaign to inform producers and encourage them to participate in the program. Environmental diagnoses are then performed on interested producers' farms. With better knowledge of the benefits and risks to the environment associated with agricultural activity, it is possible to more accurately identify the BMPs suited to each case. Thus this preliminary process is not only required to identify the BMPs, it also helps the implicated farmers become more environmentally aware.

Once all the BMPs have been identified, the auction system begins. Producers then make proposals specifying the BMP portfolio that they are willing to implement as well as the amount of money that they would like to receive for this service (*willingness to accept*). EBIs will then be calculated taking into account the environmental benefits obtained (through implementing a set of BMPs).

The farmers' proposals will be selected on the basis of their cost-effectiveness, i.e., their ability to produce EG&S at the lowest cost. Proposals will be ranked according to their EBIs/prices ratio, with the most effective (i.e., those with the highest EBI at a lower price) being chosen first. The others will then follow in descending order of environmental benefit ratio. The last proposal selected will be the one that produces an EG&S that achieves the target environmental objective for the watershed in question.

The final steps in the process involve implementing the BMPs and obtaining the resultant EG&S.

In designing an agro-environmental policy based on an auction system, we have studied current practice, especially the Conservation Reserve Program in the United States and the BushTender and EcoTender programs in Australia.

A number of factors must be considered when developing an agro-environmental policy based on an auction system, including the target environmental objectives and the auction format (Stoneham, 2002).

The target EG&S are the same as in the case of the policies described above, i.e., better water quality through less phosphorus in the water and habitat creation (forests and wetlands).

On the basis of the auction formats used in the U.S.A. and Australia, we have opted for an auction mechanism with the following features: first price, single-round bidding and public proposals. Through this system, producers learn about the environmental impact of applying BMPs but are not informed about the value of the natural resources on their property. The reasons for these choices are outlined below.

According to the Organization for Economic Co-operation and Development (OECD, 2007b), the difference between a first-price auction and a second price auction is that in a first-price auction, the final auction price will be that of the participant who has made the highest bid. However, in a second-price auction, the highest bidder wins the auction, but pays the amount of the second highest bid. We have chosen the first-price auction for simplicity's sake.

We have also opted for a single-round mechanism because, according to Eigenraam et al. (Eigenraam et al., 2005), multiple-round mechanisms increase policy transaction costs. Moreover, sealed proposals will be used when the number of auction participants is low. There is a possibility of collusion between participants when they are few in number, which would increase the price of the proposals made. However, in the case of auctioned natural resource management contracts, the number of participants is generally more than 50, and the risk of collusion is low. We will therefore opt for an auction system with public proposals.

The decision to give only partial information to producers is based on the fact that, in the U.S.A. and Australia, it was found that revealing information to producers led to higher proposal prices. To avoid this, we have chosen to reveal only some information to the producers participating in the program.

All farmers are eligible for the program with respect to all their owned or rented land, except for certain practices that necessitate an initial investment, in which case only owned land is eligible. The BMP portfolio varies for each farm, because the lists of on-farm BMPs to be implemented are prepared by the producers themselves. As in the case of annual payments, the contract period will be three years, renewable twice.

Since the auction system is an effective market mechanism capable of achieving the target EG&S objectives at the lowest cost, we assume that the most effective practices will be implemented first. In fact, according to Stoneham et al. (Stoneham et al., 2007), the Australian experience shows that market-based policy instruments (auctions, tradable permit systems, etc.) create an economic environment in which farmers are capable of making the optimal choice between producing commodities and creating EG&S. It is assumed that proposal prices will correspond to the producers' net private cost plus their private transaction costs. Public transaction costs are expected to be higher than in the case of annual and one-time payments because of the heavier administrative burden involved in setting up auction programs, especially in terms of the amount of information required to establish environmental objectives.

Table 15 summarizes the main features of a policy based on an auction mechanism.

TABLE 15 : FEATURES OF AN AUCTION-BASED POLICY FOR IMPLEMENTING BMPS

Policy features	Province	
	Quebec	**Manitoba**
Type of auction	First price, single round, public proposals, partial information.	
Eligibility	▪ All farmers and for all their owned or leased land ▪ Exception: For certain practices that either involve an alternative land use (i.e., crop reduction on agricultural flood planes) or require investment (treed riparian buffer strips), only landowners are eligible. ▪ Winning proposals: > EBI/price ratio	
Eligible BMPs	▪ Grassy or wooded buffer strips 10 m wide ▪ Conservation tillage (no-till and reduced till) ▪ Cover crops ▪ Intercropping ▪ Conservation of woodlands in agricultural areas ▪ Conservation of wetlands in agricultural areas ▪ Crop reduction on agricultural floodplains.	▪ Grassy or wooded buffer strips 10 m wide ▪ Conservation of wetlands in agricultural areas ▪ Manure storage ▪ Cover crops
Technical support	Yes, for certain BMPs (i.e., buffer strips)	
Contract period	Three years, renewable twice	
Penalties	▪ Farmers who do not meet their contractual commitments are not paid for the year in question. ▪ Farmers wishing to terminate their contracts early will be required to pay half the annual amount of the remaining years (penalty modelled on the ALUS pilot project and the Greencover Canada program).	

2.1.5. Effluent Trading Schemes[9]

Initially developed and applied with respect to air pollution in the United States, such schemes have flourished in the water quality improvement field. In this section, we will consider measures to improve water quality by reducing phosphorus-containing effluent from agricultural operations. See appendix 10 for more information on effluent trading systems.

[9] This section is based on a report produced by the CAAAQ (a commission set up to study the future of agriculture and the agri-food industry in Quebec) entitled: [translation] *Phosphorus effluent trading as a solution to watercourse contamination in Quebec watersheds*.

The effluent trading process is based on the fact that the costs of reducing pollution to a given target level are not uniform between system participants. Different pollution sources have different abatement costs, which is the basis for the motivation to trade. In fact, sources with high pollution control costs prefer to buy reductions or effluent permits from lower-cost sources rather than reducing their own effluent. Moreover, sources that have low reduction costs have an incentive to lower their effluent more than their permit requires, since they can then sell their effluent rights at a higher price than their reduction costs. Society thus wins largely because market forces achieve a given environmental objective by reducing effluent where this can be done at the lowest cost.

Designing a Policy Based on Effluent Rights Trading

The design of a policy based on tradable permit systems is based on existing practices in the United States and Australia and on a pilot project in Ontario.[10]

A system of tradable permits is not applicable in all contexts, but where such systems are feasible, certain requirements still need to be met. First, general operation of the program should be based on identifying a particular environmental problem and specifying water quality objectives in the form of maximum permissible loads of a pollutant (phosphorus) in watercourses. In the U.S.A., for example, maximum daily loads are established in the form of an indicator called Total Maximum Daily Load (TMDL). The TMDL is the sum of all the permitted discharge of a pollutant from all point and non-point sources, plus a safety margin to take into account unforeseen factors. This approach also considers seasonable variations in water quality.

There are also bound to be point sources of pollution within the territory covered by the program, such as a municipal wastewater treatment plant or an industry, that seek to increase discharge capacity to meet growth needs. In such cases, the enterprises concerned must obtain a phosphorus effluent permit from the provincial government.[11] The province must then agree to intervene, if required, to ensure that the market operates properly. Since they are not able to increase their level of phosphorus effluent, point sources face the option of either investing in new technology to reduce effluent or purchasing effluent credits from other program participants that have succeeded in reducing their emissions at a lower cost.[12] These choices are largely dictated by the relative cost of these two options.

[10] The Ontario Ministry of the Environment has assigned an institutional value to the phosphorus reduction coefficients used in the pilot project in Ontario.
[11] Water pollution at the local level falls under the provincial government's jurisdiction.
[12] For example, farmers through implementation of BMPs

In the two watersheds being considered, water quality problems exist, particularly in terms of phosphorus levels exceeding the load limits respectively established by the two provinces. According to a description of the Nicolet watershed environment (Ghazal, 2006), a number of point sources of phosphorus effluent exist within the watershed, notably industries and municipalities.

In fact, municipalities and industries also need to respect existing environmental standards for discharging phosphorus into watercourses. There is also a need to consider increasing pollutant emission levels, particularly because of population growth within the watershed. It is also assumed that the growth strategies of some industries imply a greater need to discharge phosphorus into watercourses. Thus conditions in the Nicolet watershed are likely to be conducive to setting up a permit trading system.

However, this is not the case in the Little Saskatchewan River watershed, where the relative scarcity of large potential purchasers of credits could be a challenge in developing a nutrient trading scheme. To solve this problem, we assume that the City of Winnipeg is likely to be a purchaser of credits, so a permit trading system could be implemented in the Little Saskatchewan River watershed case. In cases where several point sources are interested in purchasing phosphorus reduction credits from other program participants in the watershed, an organization is created (in the Ontario project, this organization is called the South Nation Conservation Authority), whose primary role is to channel this emerging market.

The next stage consists in establishing the reduction ratio needed to offset an increase in phosphorus discharge. Generally speaking, this ratio is 2:1, i.e., for a point source to increase its phosphorus effluent by 1 kilogram, it must purchase the equivalent of a 2-kilogram reduction in phosphorus from another program participant. For the South Nation River in Ontario, the Ontario Ministry of the Environment has raised this ratio to 4:1 (instead of 2:1, as initially proposed). This ratio reflects the uncertainty associated with reduction calculations, but is also the result of local consensus.

The value of one kilogram of total phosphorus excluded from watercourses must then be set. This also varies in the different case studies. In the South Nation case, for example, the price of a kilogram of phosphorus excluded from watercourses has been set at $375, which also covers the regulatory organization’s expenses for administration, monitoring and report preparation.

The point sources pay the regulatory body an amount corresponding to the reduction credits desired. With this budget, it is possible to issue a call for proposals to farmers who might want to participate in the program and thereby be paid for implementing BMPs to reduce phosphorus discharge into watercourses. Then the next step is to develop a system for tracking phosphorus levels and reporting the results to the regulatory body and the other related stakeholders.

The quantity of phosphorus traded will depend on two factors: (1) the quantity of phosphorus discharged into the watercourse from the point sources and (2) the ratio applied to the reductions from non-point sources.

Like the auction system, this is another effective market mechanism in terms of policy cost. , BMPs capable of producing greater reductions in phosphorus at the lowest cost will be implemented first. Only the public transaction costs will be different with this mechanism. Note that the decision to certify credits increases its public transaction costs. Table 16 summarizes the main features of a tradable permit policy for implementing BMPs on farms.

TABLE 16 : FEATURES OF A TRADABLE PERMIT POLICY FOR IMPLEMENTING BMPS

Policy features	**Province**	
	Quebec	**Manitoba**
Eligibility	▪ All farmers and all their land owned or leased ▪ Exception: For certain practices that either involve an alternative use (i.e., crop reduction on agricultural floodplains) or require investment (e.g., treed riparian buffer strips), only landowners are eligible.	
Eligible BMPs	▪ Grassy buffer strips 10 m wide ▪ Conservation tillage (no-till and reduced till) ▪ Cover crops ▪ Intercropping.	▪ Grassy buffer strips 10 m wide ▪ Manure storage ▪ Cover crops
Technical support	Yes, for certain BMPs (i.e., riparian buffer strips)	
Contract period	▪ Three years, renewable twice	
Penalties	▪ Farmers who do not meet their contractual commitments are not paid for the year in question. ▪ Farmers wishing to terminate their contracts early will be required to pay half the annual amount of the remaining years (penalty modelled on the ALUS and Greencover Canada programs).	

2.2. BMPs Associated to Policies

2.2.1. Choice of BMPs

This section identifies and briefly describes all BMPs chosen to achieve the target levels of EG&S.

Table 17 summarizes the various BMPs chosen in the two case studies.

TABLE 17 : BMPS IMPLEMENTED IN THE TWO CASE STUDIES

	Water quality (phosphorus)	Habitat (wetland and woodland)	
		Wetlands	Woodland
Nicolet (Quebec)	• Riparian buffer zones (wooded and grassy, 10 m) • Winter cover crops (for cereals and corn) • Conservation tillage (no-till and reduced till)	• Removing lands prone to flooding from production • Conservation of existing wetlands in agricultural zones	• Conservation of existing forests in agricultural zones
Little Saskatchewan River (Manitoba)	• Wooded riparian buffer zones (10 m) • Converting marginal farmland to wetlands • Winter cover crops • Conservation tillage (no-till) • Manure storage	• Converting marginal farmland to wetlands	• Wooded riparian buffer zones (10 m)

Water Quality (phosphorus)

The choice of suitable BMPs for achieving target EG&S levels is first determined by the availability of information on the impact of each practice, especially for phosphorus. Of the existing coefficients of effectiveness in the literature, we have selected those of the South Nation Conservation Authority (2003) for their reduced information requirements and their ease of use. These coefficients are used under the Total Phosphorus Management program pilot experience of the Ontario Ministry of Environment on water quality trading in the South-Nation watershed. We are aware of the fact that these coefficients are relative and debatable with respect to the scientific uncertainties and the importance of the biophysical conditions (soil, climate, topography, etc.) associated with the reduction of phosphorus. However, we have decided to use the South Nation coefficients because they allow us to evaluate the impact of each BMP on a relatively equitable basis since they are established based on a consensus of several experts from Ontario and on a comprehensive review of BMP literature.

Closer to the Canadian Prairies, BMP efficiency rates have also been applied by the Idaho Soil Conservation Commission (ISCC) for a water quality trading program in the Lower Boise Watershed (ISCC, 2002). The efficiency rates do not differ significantly from those of South Nation Conservation Authority. For example, the Idaho Soil Conservation Commission’s efficiency rate for a riparian buffer zone is 55%, while South Nation Conservation Authority lists the efficiency as 56% to 67%, depending on width (ISCC, 2002; South Nation Conservation Authority, 2003). South Nation Conservation Authority’s efficiency rates are primarily used in this study except for the BMP “wetland restoration”, whose coefficient is taken from the Lower Boise study.

Because the South Nation coefficients for phosphorus have been established for only ten practices, our choice of BMPs for phosphorus is limited to the following list:

1) Milkhouse wastewater
2) Manure storage facilities
3) Clean water diversion
4) Livestock access to watercourses
5) Septic systems
6) Conservation cropping
7) Cover cropping
8) Buffer strips
9) Fragile land retirement
10) Nutrient management

Because it is not specific to agriculture, the sceptic system BMP is automatically eliminated. Clean water diversion is also abandoned because of the data needed to comply with the formula. Moreover, several BMPs are already regulated in Quebec: milkhouse wastewater, manure storage facilities, livestock access to watercourses, nutrient management (PAEF) and 3-metre-wide riparian buffer zones. As a consequence, these BMPs are not considered in Quebec because of the voluntary character of the policies under study. Fragile land retirement is eliminated because of its negligible impact on phosphorus in the watershed: there are only 37 ha of cultivated land prone to flooding on the Nicolet, and no other data on fragile agricultural land was readily available. The remaining BMPs (conservation cropping, cover cropping and buffer strips wider than 3 m) are all considered.

The situation is somewhat different in Manitoba, where these BMPs are not regulated (with the exception of manure storage, which applies only to operations over 300 animal units), leaving a significantly larger set of choices. The BMPs that are finally selected for the Little Saskatchewan River are: (1) wooded riparian buffer zones (10 m), (2) converting marginal farmland to wetlands, (3) winter cover crops, (4) conservation tillage (no-till), and (5) manure storage.

Habitat

In the case of habitat, the choice of BMPs is straightforward in both watersheds. For the Nicolet sub-watershed the proposed BMPs are (1) removing lands prone to flooding from production, (2) conservation of existing wetlands, and (3) conservation of existing forests. For the Little Saskatchewan River, they are (1) converting marginal farmland to wetlands and (2) the implementation of wooded riparian buffer zones (see Table 17).

A comparison between habitat and phosphorus BMPs (listed in Table 17) reveals that on the Little Saskatchewan River, the two groups intersect: all habitat BMPs also account for their impact on phosphorus, which is not the case in Quebec where (1) conservation of existing habitat doesn't change the actual level of phosphorus in the river while (2) removing lands prone to flooding from production does, but the impact is marginal because the floodplain farmland is quite small (37 ha). An important consequence is that the habitat EG&S in Manitoba doesn't imply any additional cost once the phosphorus target is reached. For this reason, it is treated as a co-benefit of phosphorus BMPs.

Each BMP chosen for this study is briefly presented in Table 18. This table also points out the watershed corresponding to each BMP. A more detailed description of each BMP is presented in Appendix 8.

TABLE 18 : DESCRIPTION OF THE BMPS CHOSEN FOR THIS STUDY

BMP	Description	Nicolet	Little Saskatchewan
Water Quality			
Manure Storage	An ideal storage system should prevent nutrient loss during storage and provide enough capacity until the field is safely covered.		√
Riparian Buffer Zones	Riparian buffer zones play an important role, not only in protecting water and habitat quality, but also in regularizing water flows and stabilizing banks.	√	√
Conservation Tillage (Reduced Till and No-till)	Conservation tillage is a beneficial management practice that leaves at least 30% of the soil surface covered by residues (stems, leaves, straw from the previous harvest) after seeding.	√	√
Cover Crops	Cover crops offer protection in periods when commercial crops cannot be grown. They reduce the amount of soil and nutrients moving toward surface waters.	√	√
Converting Marginal Farmland to Wetlands	This practice involves transforming less productive agricultural land into wetlands so they can decrease the level of phosphorus that leaches into rivers.		√
Habitat			
Converting Marginal Farmland to Wetlands	This practice involves transforming less productive agricultural land into wetlands so they can serve as habitats for various wildlife species.		√
Riparian Buffer Zones	Riparian buffer zones play an important role, not only in protecting water and habitat quality, but also in regularizing water flows and stabilizing banks.		√
Conservation of Existing Wetlands and Forests in Agricultural Zones	This BMP involves preserving wetlands and forests in farming areas, since these environments are all crucial for wildlife.	√	
Removing Lands Prone to Flooding from Production	This practice involves restoring agricultural floodplains to their natural state so they can serve as habitats for various wildlife species.	√	

2.2.2. Estimation of the Impact of BMPs on Water Quality and Habitat

As stated in section "2.2.1 Choice of BMPs", the impact of BMPs on phosphorus loadings is calculated based on efficiency coefficients established by the South Nation Conservation Authority (South Nation Conservation Authority, 2003).

Table 19 shows these coefficients before and after updating. We have used the updated values where they exist. We are cautious in our calculations inasmuch as all parameters are assessed at their most likely values.

TABLE 19 : SOUTH NATION EFFICIENCY COEFFICIENTS FOR THE IMPACT OF SEVERAL BMPS ON PHOSPHORUS LEVELS

Current phosphorus loading algorithms used in the Rural Water Quality Program:

Best Management Practice	Calculation Kg of P per year controlled
Milkhouse	# of cows x 1.26 kg/year
Manure Storage Facility	# of animals x animal phosphorus factor x days x 0.04
Clean Water Diversion	# of animals x animal phosphorus factor x days x 0.02
Livestock Access	# of animals x animal x phosphorus factor x days x 0.02
Septic systems	# systems x 15.33 Kg/system/yr (direct)
	#systems x 0.6 Kg/system/yr (indirect)
Conservation Cropping	0.75 kg x hectares
Cover Cropping	0.4 kg x hectares
Buffer Strip	0.7 kg x hectares
Fragile Land Retirement	0.7 kg x hectares
Nutrient Management	25 kg x hectares x 0.1

Proposed new updated phosphorus loading algorithms:

Best Management Practice	Calculation Kg of P per year controlled
Milkhouse	# of cows x 0.69 kg/year (excluding manure) # of cows x 2.76 kg/year (including manure)
Manure Storage Facility	# of animals x days x phosphorus excreted x 0.30 (feedlot manure) # of animals x days x phosphorus excreted x 0.07 (dairy pile manure)
Clean Water Diversion	# of animals x days x phosphorus excreted x phosphorous leached x (reduced feedlot runoff vol. / original feedlot runoff vol.) (phosphorous leached =0.30 for feedlot and 0.07 for dairy manure stockpile)
Livestock Access	# of animals x days x phosphorus excreted x 0.03 (multiply by 0.5 for animals with half day access to watercourse)
Septic systems	P savings = P loading (failed) – P loading (functional) Where P loading = 0.6 Kg TP ca-1 year -1 * (#persons) * (1-A)
Conservation Cropping	0.50 kg/ha x hectares (no-till)
Cover Cropping	0.4 kg x hectares (not updated)
Buffer Strip	0.67 kg x hectares (for a 6-10 m buffer)
Fragile Land Retirement	0.7 kg x hectares (not updated)
Nutrient Management	25 kg x hectares x 0.1 (not updated)

Source: South Nation Conservation Authority (2003).

2.2.2.1. Central and Eastern Canada (Quebec)

As previously seen, the Nicolet sub-watershed is the one identified as the most representative agricultural watershed in Quebec and thus in Central and Eastern Canada. Our analysis therefore attempts to quantify the impact of BMPs on EG&S levels within the Nicolet watershed. As in any analysis of this kind, assumptions are needed to facilitate calculation and interpretation. These assumptions are described below. Thus the characteristics analyzed reflect available data and therefore represent the territory's present situation.

The following section offers some insight into the estimation of each BMP's impact on phosphorus. In order to facilitate comparisons between BMPs, we fix an 85% level-of-uptake target for all practices. This level of uptake is considered a realistic maximum and could change (drop off) when portfolios of BMPs are formed for each policy. It is worth underlining that neither of the BMPs available in Quebec individually achieves the target of 0.036 mg/L. However, this target seems attainable when several BMPs are implemented.

Water Quality BMPs

10 m Riparian Buffer Zones

The situation of Quebec's riparian zones reflects the fact that the Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Flood plains forces farms to maintain a minimum three-metre shoreline strip in its natural state. Yet a number of farm-sector stakeholders have campaigned to have the government increase this minimum width. This is one of the main reasons why the 10 m riparian zone has been made a target. Even so, riparian zones wider than 10 m would be better for creating environmental goods and services (see Figure 16 in Appendix 8).

In spite of the fact that only 51% of farming enterprises crossed by waterways in Centre-du-Québec respected the riparian zones of three metres in 2003 (BPR, 2005), we suppose that 85% of agricultural producers respected the 3 m riparian zones. This hypothesis is derived from the more general one that considers the actual level of legislation as the baseline for the creation of EG&S. Table 20 shows the procedure for estimating the impact of 10 m riparian zones on phosphorus levels in the Nicolet sub-watershed. The bottom line shows that the target concentration of 0.036 mg/L is not achieved by this BMP, even at an 85% acceptance rate (0.038 mg/L). This is mainly due to the fact that the 3 m riparian zones already captures 0.56 kg P/ha, while the additional 7 m captures 0.11 kg P/ha.

In the next chapters two alternative riparian zones are considered: wooded and grassy. This differentiation has an impact on the costs of implementation and maintenance as well as on the co-benefits generated by riparian buffers, but no distinction is made on the phosphorus level because the coefficients of South Nation consider a unique number for all types of riparian buffers.

TABLE 20: ESTIMATED IMPACT OF 10 M RIPARIAN ZONES ON PHOSPHORUS LEVELS IN THE NICOLET SUB-WATERSHED

Target level of uptake of 10 m riparian zones (A)	85%
Current level of uptake of 10 m riparian zones [13] (B)	0%
Level of uptake of 3 m riparian zones[14] (C)	85%
Phosphorus controlled by a 10m riparian zone (kg/cultivated ha)[15] (D)	0.67
Phosphorus controlled by a 3 riparian zone (kg/cultivated ha)[16] (E)	0.56
Cultivated area within a 700 m width buffer zone catchment (ha)[17] (F)	28,478
Phosphorus controlled by this BMP (kg/year) (G) = (A-B)*F*(D-E)	2,663
Phosphorus loading at 85% uptake of regulated BMPs (kg/year)[18] (H)	38,262
Phosphorus loading after this BMP is adopted (kg/year) (I) = H - G	35,600
Flow (hm^3/year) (J)	937
Phosphorus concentration after this BMP is adopted (mg/l) (K) = I/J	**0.038**

Conservation Tillage

After consulting several agronomists from the Nicolet watershed, two forms of conservation tillage are considered for this watershed: no-till (or zero-till) and reduced till. Both of them seem to be popular among agricultural producers of this region. Because the available data does not allow us to distinguish between the current adoption rates of these two practices, we estimate the aggregated impact on

[13] Because no information was available for the current adoption rate of 10 m riparian zones, we suppose that no 10 m riparian zone is already implemented on the Nicolet sub-watershed.
[14] Because 3 m riparian zones are already regulated, we assume that 85% of agricultural producers respect this regulation.
[15] South Nation Authority (2003).
[16] South Nation Authority (2003).
[17]Because no scientific basis was found for the width of the buffer zone catchment of a riparian zone, the 700 m width was chosen based on a discussion with a researcher familiar with the Nicolet watershed, who found this number reasonable. The buffer zone catchment area was obtained via GIS data computed by Del Degan Massé, a subcontractor. See

Appendix 7 for more explanations and an illustration.
[18] See

Appendix 6 for detailed computations.

phosphorus and consider that half of the target is achieved by one practice, and the other half by the other practice.

Because the coefficient for reduced-till is not updated by the South Nation Authority (South Nation Authority, 2003), we estimate this coefficient based on the coefficient of no-till and some conclusions from Vallières (Vallières, 2004) (see Table 21). We find that the no-till is 70% more efficient than reduced-till in preventing phosphorus from leaching into the River. Multiplying the 0.5 kg P/ha coefficient for no-till estimated by South Nation Authority (South Nation Authority, 2003) by the 70% estimated in Table 21, we find a 0.35 kg P/ha coefficient for reduced-till.

TABLE 21 : EFFICIENCY OF REDUCED-TILL WITH RESPECT TO NO-TILL

	Phosphorus losses over 3 periods (kg P) (A)	**Phosphorus losses with respect to conventional tillage (kg P) (B) = 115.4 – (A)**	**Phosphorus losses with respect to conventional tillage (%) (C) = (B)/115.4**	**Efficiency of reduced-till with respect to no-till (D) = $(C)_{reduced\text{-}till}/(C)_{no\text{-}till}$**
Conventional tillage	115.4	-	-	
Reduced-till	58.1	57.3	49.65%	
No-till	33.3	82.1	71.14%	**70%**

Source: Vallières (2004) and our computations.

Table 22 shows the procedure for estimating the impact of conservation tillage on phosphorus levels in the Nicolet sub-watershed. The bottom line shows that the target concentration of 0.036 mg/L was not achieved by this BMP, even at an 85% acceptance rate (0.037 mg/L).

TABLE 22 : ESTIMATED IMPACT OF CONSERVATION TILLAGE ON PHOSPHORUS LEVELS IN THE NICOLET SUB-WATERSHED

Target level of uptake (A)	85%
Current level of uptake (in 2003)[19] (B)	41%
Annual crop areas (ha)[20] (C)	20,051
Annual crop areas where conservational tillage is used (ha) – target (D) = C * A	17,043
Annual crop areas where conservational tillage is used (ha) – current (E) = C * B	8,221
Annual crop areas where conservational tillage is used (ha) – additional (F) = D - E	8,822
of which, 50% no-till (G) = 0.5*F	4,411
and 50% reduced-till (H) = 0.5*F	4,411
Phosphorus controlled by no-till (kg/ha)[21] (I)	0.50
Phosphorus controlled by reduced-till (kg/ha)[22] (J)	0.35
Phosphorus controlled by no-till (kg/year) (K) = I*G	2,206
Phosphorus controlled by reduced-till (kg/year) (L) = J*H	1,544
Phosphorus loading at 85% uptake of regulated BMPs (kg/year)[23] (M)	38,262
Phosphorus loadings after this BMP is adopted (kg/year) (N) = M-K-L	34,513
Flow (hm^3/year)[24] (O)	937
Phosphorus concentration after this BMP is adopted (mg/l) (P) = N/O	**0.037**

COVER CROPS

This practice may be used on areas planted in wide row crops such as corn as well as on areas planted in close row crops such as cereals. Table 23 shows the procedure for estimating the impact of cover crops on phosphourus levels in the Nicolet sub-watershed for cereals, while Table 24 shows the same procedure in the case of cover crops for corn. The bottom line shows that the target concentration of 0.036 mg/l is not achieved by this BMP, even at an 85% acceptance rate (0.039 mg/l in the case of cereals and 0.037 mg/l in

[19] BPR (2005), Table A.10, for the Centre-du-Québec region.
[20] Computed from the 2006 Census of Agriculture data for municipalities that have more than 50% of their area inside the Nicolet sub-watershed.
[21] South Nation Authority (2003).
[22] South Nation Authority (2003), Vallières (2004) and our computations.
[23] See

Appendix 6 for detailed computations.

[24] Gangbazo (2005b), Table 3.2.

the case of corn). While the efficiency per hectare is the same for the two practices (0.4 kg p/ha), more phosphorus is retained via the cover crops for corn for two reasons: (1) this practice is not adopted at all on this watershed and (2) the areas of corn are much larger than those of cereal (12,027 ha of corn and 5,561 ha of cereals in 2006).

TABLE 23 : ESTIMATED IMPACT OF COVER CROPS FOR CEREALS ON PHOSPHORUS LEVELS IN THE NICOLET SUB-WATERSHED

Target level of uptake (A)	85%
Current level of uptake (in 2003)[25] (B)	18%
Closed-row crop areas (ha)[26] (C)	5,561
Closed-row crop areas where cover crops are used (ha) – target (D) = C * A	4,727
Closed-row crop areas where cover crops are used (ha) – current (E) = C * B	1,001
Closed-row crop areas where cover crops are used (ha) – additional (F) = D - E	3,726
Phosphorus controlled by cover crops (kg/ha)[27] (G)	0.4
Phosphorus controlled by cover crops (kg/year) (H) = F*G	1,490
Phosphorus loading at 85% uptake of regulated BMPs (kg/year)[28] (I)	38,262
Phosphorus loadings after this BMP is adopted (kg/year) (J) = I-H	36,772
Flow (hm^3/year)[29] (K)	937
Phosphorus concentration after this BMP is adopted (mg/l) (L) = J/K	**0.039**

[25] Computed from the 2006 Census of Agriculture data for municipalities that have more than 50% of their area inside the Nicolet sub-watershed.
[26] Computed from the 2006 Census of Agriculture data for municipalities that have more than 50% of their area inside the Nicolet sub-watershed.
[27] South Nation Authority (2003).
[28] See

Appendix 6 for detailed computations.
[29] Gangbazo 2005b, Table 3.2.

TABLE 24 : ESTIMATED IMPACT OF COVER CROPS FOR CORN ON PHOSPHORUS LEVELS IN THE NICOLET SUB-WATERSHED

Target level of uptake (A)	85%
Current level of uptake (in 2003)[30] (B)	0%
Corn areas (ha)[31] (C)	12,027
Corn areas where cover crops are used (ha) – target (D) = C * A	10,223
Corn areas where cover crops are used (ha) – current (E) = C * B	0
Corn areas where cover crops are used (ha) – additional (F) = D - E	10,223
Phosphorus controlled by cover crops (kg/ha)[32] (G)	0.4
Phosphorus controlled by cover crops (kg/year) (H) = F*G	4,089
Phosphorus loading at 85% uptake of regulated BMPs (kg/year)[33] (I)	38,262
Phosphorus loadings after this BMP is adopted (kg/year) (J) = I-H	34,173
Flow (hm^3/year)[34] (K)	937
Phosphorus concentration after this BMP is adopted (mg/l) (L) = J/K	**0.037**

Habitat BMPs

Removing Lands Prone to Flooding from Production

37.07 ha of lands prone to flooding are found on the Nicolet sub-watershed (Del Degan Massé, 2008).

Conservation of Existing Wetlands and Forests in Agricultural Zones

The Nicolet sub-watershed has 27,511 ha of forests and 387 ha of wetlands in agricultural areas (Del Degan Massé, 2008).

2.2.2.2. Western Canada (Manitoba)

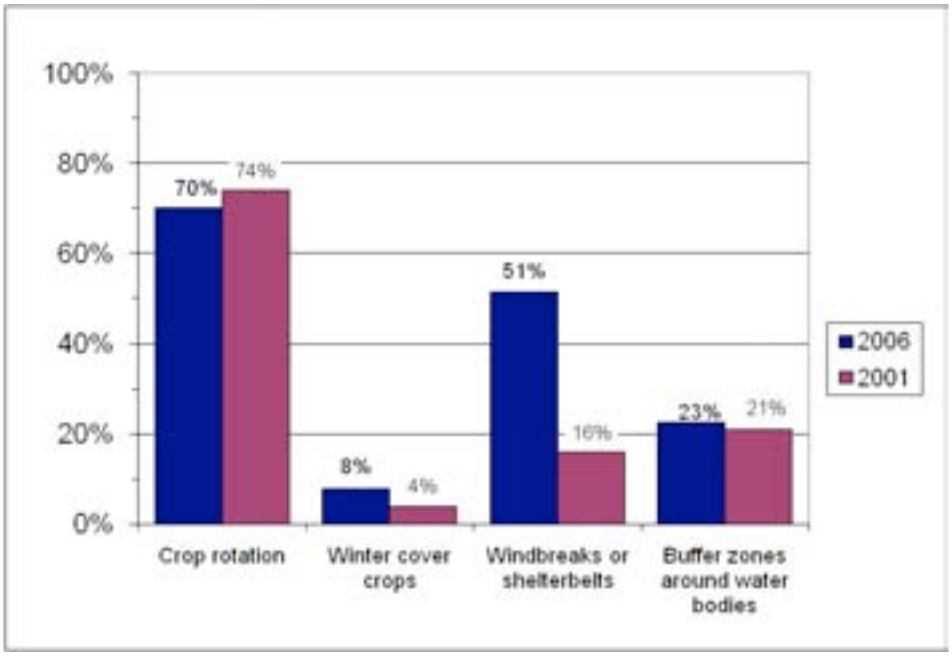
30 This hypothesis is based on a conversation with an agronomist of the Nicolet region.
31 Computed from the 2006 Census of Agriculture data for municipalities that have more than 50% of their area inside the Nicolet sub-watershed.
32 South Nation Authority (2003).
33 See Appendix 6 for detailed computations.
34 Gangbazo 2005b, Table 3.2.

Farming practices in the Little Saskatchewan River Watershed are diverse and are constantly undergoing changes. Recent initiatives that may have influenced farming practices in the watershed include the National Farm Stewardship Program, the ALUS Pilot project, and Manitoba Habitat Heritage Corporation's conservation easement program.

The implementation of these programs has led to changes in land use practice. The percentages of the watershed's 700 farmers who report having shelterbelts, winter cover crops and riparian buffer zones increased between the 2001 and 2006 censuses (see Figure 2) (AAFC, 2004; Statistics Canada, 2007). Regarding tillage practices, the acreage of low-till and zero-till farming also increased between 2001 and 2006 (see Figure 3) (AAFC, 2004; Statistics Canada, 2007).

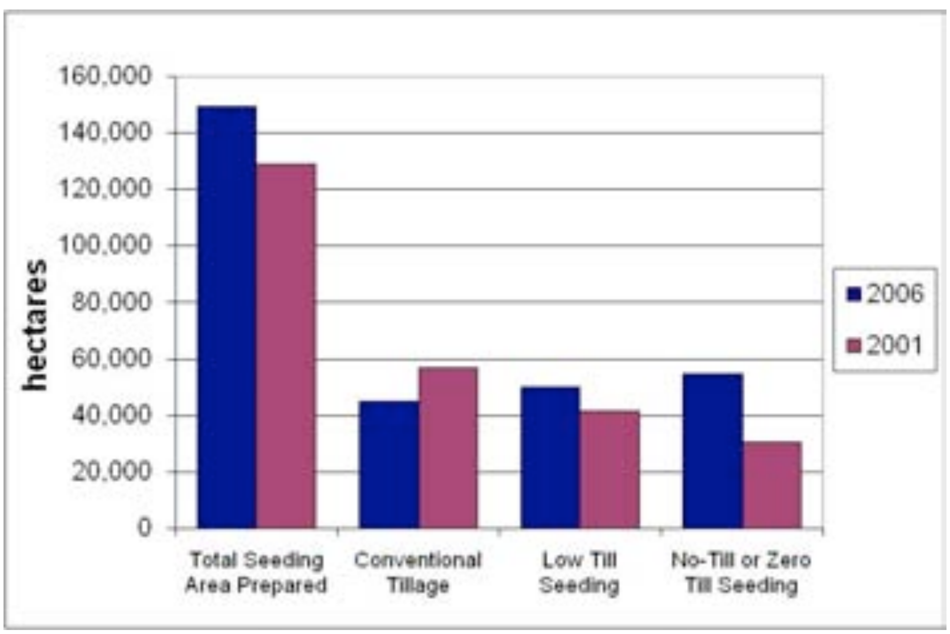
This section details the level of implementation required of each BMP in order to achieve a 75% reduction in phosphorus loading for a runoff concentration of 0.05 mg/L and for maintenance and enhancement of wildlife habitat. In this analysis, BMP efficiency rates from South Nation Conservation Authority (South Nation Conservation Authority, 2003) are primarily used.

FIGURE 2 : PERCENTAGE OF FARMERS IN LITTLE SASKATCHEWAN WATERSHED REPORTING THE USE OF BMPS IN THEIR OPERATIONS IN 2001 AND 2006



Source: Statistics Canada (2007).

FIGURE 3 : AREA OF FARMLAND AND TILLAGE PRACTICES IN THE LITTLE SASKATCHEWAN RIVER WATERSHED IN 2001 AND 2006



Source: Statistics Canada (2007).

Riparian Buffer Zones

The level of implementation required for riparian buffer zones depends to a large extent on the assumptions made about the effectiveness of the BMP. In Manitoba, there has been considerable discussion on their effectiveness. Much of the runoff from farmland occurs in spring after snowmelt, and the effectiveness of buffer zones at removing this runoff is the subject of study (Zurba, 2007). While their effectiveness remains the subject of study, the Government of Manitoba cites buffer zones as a measure to reduce agricultural runoff and increase wildlife habitat (MAFRI, 2008; Manitoba Riparian Health Council, 2008). In this analysis, riparian zone effectiveness came from the South Nation Conservation Authority (South Nation Conservation Authority, 2003), which accepts that a ten metre buffer zone reduces P loading by 0.67 kg per hectare of land.

The Agricultural lands in the Canadian Prairie provinces are surveyed in sections of one square mile. Sections are often divided into quarters. Since sections are generally surrounded by road allowances with ditches, it has been assumed that riverbanks will receive runoff from up to 400 m away, or half the width of one quarter section. Runoff from further than 400 m away has been assumed to run unbuffered into road ditches.

According to the stream lengths presented in Table 79, there is a total of approximately 286 km of permanent and intermittent streams running through agricultural land. The total length of riparian areas in farmland is therefore approximately 554 km. It has been assumed that riparian buffer zones will have a catchment of 400m, for a total protected area of 22,160 ha. If riparian buffer zones are applied to these 22,160 ha, then the total potential reduction in phosphorus loading will be 14,847 kg or 14.8 tonnes with 10 m buffer zones. This is the theoretical maximum potential phosphorous loading that could be achieved with riparian buffer zones in the Little Saskatchewan watershed.

- BMP P removal: 0.67 kg/ha/year (10 m buffer)
- Unbuffered riverbank length: 554 km
- Buffer zone catchment: 400 m
- Potential protected area: 22,160 ha
- Maximum potential loading reduction: 14.8 t/yr (10 m buffer zone)

Riparian buffer zones also create habitat. The maximum potential increase in habitat from riparian buffer zones in the Little Saskatchewan watershed from implementing 10 m buffer zones along the 554 km of unbuffered land will be 554 ha:

- Buffer zone length: 554 km of shoreline
- New riparian habitat: 554 ha (10 m buffer)

Cover Crops

The uptake of cover crops is a complex issue. The decision whether to apply a cover crop depends to a large extent on commodity prices, weather patterns, and climate. While it might be economically feasible to plant a cover crop in one year, it may be unfeasible in other years.

Cover crops have the ability to reduce runoff, which in turn reduces nutrient and chemical losses. The review conducted by South Nation Conservation Authority (South Nation Conservation Authority, 2003) established P loss reduction from cover crops to be 0.4 kg per hectare under cover crop. In the 2001 Agricultural Census of Canada (Statistics Canada, 2007), it was reported that 4% of farmers reported having winter cover crops on their land. It is therefore assumed if 4% of land is under cover, then 176,149 ha of agricultural land is not under a cover crop. Using the P removal rate of 0.4 kg/ha, an additional 32%, or 56,367 ha, of the total agricultural land will need to be under cover crops in order to achieve a 75% reduction of P loading to the Little Saskatchewan River Watershed.

- Agricultural land: 183,488 ha
- Agricultural land not under cover crop: 176,149 ha
- Cover crop P loading decrease: 0.4 kg/ha
- Land required for 22 t/yr reduction: 56,367 ha (32% of total cropland)

The amount of cover crops applied in the watershed increased between 2001 and 2006; however, this increase may be offset by the increase in land under cultivation over the same period.

Zero-Till

Zero-till farming rates have increased by nearly 80% in the period from 2001 to 2006 (AAFC, 2004; Statistics Canada, 2007). In 2001, the total area of farmland under zero-till was 30,644 ha, and in 2006 54,731 ha were reported to be under zero-till. The South Nation Conservation Authority (South Nation Conservation Authority, 2003) uses a P loading reduction rate of 0.5 kg/ha per year for zero-till. By applying this rate to the 149,520 ha of seeded acres of farmland in the Little Saskatchewan River

Watershed, we see that a reduction of P loading to the target level can be achieved by converting 43,890 ha of land to zero-till.

- Agricultural land prepared for seeding: 149,520 ha
- Zero-till P loading decrease: 0.5 kg/ha
- Land required for a 22 t/yr reduction: 43,890 ha (26% of total cropland)

The increase in the area under zero-till farming has increased by 24,087 ha between 2001 and 2006. Using the South Nation Conservation Authority formula, this suggests that P loading reduction has already decreased by 12 t/yr as a result of this conversion to zero-till farming. However, the total area prepared for seeding has increased over the same period, so the P loading reduction could be offset by the overall increase in production in the watershed.

Manure Storage

It is difficult to make an accurate estimate of how changes in manure storage practices can affect P loading to the Little Saskatchewan River Watershed because information on the current state of manure storage is unavailable. Manitoba's *Livestock Manure and Mortalities Management Regulation* MR42/98 is designed to apply to cattle and hog operations with over 300 animal units (A.U.). In the Little Saskatchewan River watershed there are 406 farms with a total of 58,071 cattle for an average herd of 124 head. In equivalent animal units, this works out to 41,418 A.U. for an average of 102 A.U. per farm. It is therefore assumed that this regulation is not applicable for cattle in this watershed. It is therefore possible to estimate the level of BMP implementation required to achieve a 75% level of P loading reduction. The amount of phosphorus from cattle manure in the Little Saskatchewan River Watershed is listed in Table 25. The total P produced is 2,133 kg per day. If it is assumed that this amount is stored for 100 days, we can apply the South Nation Conservation Authority loading reduction estimate for manure storage of a 30% P reduction over 200 days (South Nation Conservation Authority, 2003). According to this formula, a 22 t/yr reduction of P loading could be achieved if the manure of 18% of the cattle in the watershed is stored.

There are few dairy cattle in this watershed, so while this policy would apply to dairy cattle, it would also apply to feedlots and cow calf operations. For these operations, manure collection would be more feasible from confined livestock areas and from over-wintering facilities. Storage could be in the form of an earthen manure facility to replace manure piles, or a collection basin to store contaminated runoff from confined areas or over-wintering facilities (Manitoba Conservation, 2005; MAFRI, 2007; South Nation Conservation Authority, 2003; Alberta Agriculture and Rural Development, 2008).

TABLE 25 : PHOSPHORUS PRODUCED BY CATTLE IN THE LITTLE SASKATCHEWAN RIVER WATERSHED

Type of Animal	No. of Animals[1]	P load per Animal (kg/animal/day)[2]	Total P Produced (kg/day)	Equiv. Animal Units per Animal[3,4]	Total Animal Units
Calves under 1 year	18,436	0.006	111	0.2	3,687
Steers 1 year and over	2,162	0.02	43	0.85	1,838
Heifers 1 year and over	5,361	0.02	107	0.8	4,289
Heifers for slaughter or feeding	3,103	0.034	105	0.8	2,482
Heifers for beef herd replacement	2,503	0.034	85	0.8	2,002
Heifers for dairy herd replacement	252	0.034	9	0.8	201
Beef cows	24,728	0.065	1,607	1	24,728
Dairy cows	544	0.061	33	1.5	815
Bulls 1 year and over	981	0.033	32	1.4	1,373
Total	**58,071**		**2,133**		41,418

1 – Statistics Canada (2007).
2 – South Nation Conservation Authority (2003).
3 – Minnesota Department of Agriculture (2007).
4 – MB Conservation (2008).

- Total cows and cattle in watershed: 58,071
- Total P produced in watershed: 2,133 kg/day
- Assumed storage period: 200 days
- P loading reduction through manure storage: 30%, or
- Storage required for a 22 t/yr reduction: 17.5% of manure

(2.133 tonnes P/day * 200 days *30% = 22 tonnes)

Wetlands

Using numbers from a nutrient trading scheme for the Lower Boise River in Idaho, we can determine the amount of phosphorus loading reduced by converting land under production to wetlands. The P removal rate from the Idaho scheme is 0.9 kg/ha (ISCC, 2002). Using the removal rate of 0.9 kg/ha would imply that P loading could be reduced by converting 24,770 ha, or 15.5%, of agricultural land in the watershed to wetlands. While it is unlikely that such a high percentage of farmland would be taken out of production, it is an indication of the potential P removal possible with this BMP.

- Agricultural land: 159,137 ha
- Wetlands P loading decrease: 0.9 kg/ha
- Land required for 22 t/yr reduction: 24,770 ha (15.5% of total cropland)

In addition to the water quality benefits, wetlands are also prime wildlife habitat. Converting 15.5% of marginal cropland to wetlands would augment the total habitat of the watershed by 24,770 ha.

2.2.3. BMPs and their Adoption Rates by Policy

This section briefly reviews the practices that are chosen for each policy, the adoption rates for these practices as well as the environmental improvements that are achieved. Table 26 and

Table 27 summarize this information for the Nicolet and Little Saskatchewan Rivers respectively.

The selection of BMPs for each policy is based on several principles that are briefly summarized below. Each BMP portfolio reaches the water quality and habitat targets.

For one-time payments, we only consider BMPs that do not involve annual costs other than opportunity costs. When annual costs are involved, annual payments are automatically used because otherwise producers would have a strong incentive not to respect their obligations while still keeping the one-time payment they have already received. Thus for the Nicolet, one-time payments are used for grassed riparian buffers because no annual maintenance is needed, while annual payments are considered appropriate for wooded riparian buffer zones because they involve important annual maintenance. Using the same principle, cover crops should be financed via one-time payments because annual costs of seeding and ploughing are marginal. On the other hand, because the Nicolet's agricultural soils are considered rich in minerals, producers do not perceive the benefits of this practice and thus do not adopt it, even if annual costs are minimal. To help them bypass this barrier, annual payments that cover their annual costs are also considered for this practice, along with an initial payment for technical assistance.

The selection of BMPs for the mixed one-time/annual payments is based respectively on their cost per kilogram of phosphorus eliminated and on their cost per hectare of habitat preserved. Thus, the most efficient BMPs in terms of $ per unit of environmental benefit are chosen until environmental targets are reached. The others are eliminated.

For market-based instruments BMPs are also selected on the basis of their cost per unit of environmental benefit, but here we consider that producers receive their real cost and not the average cost estimated within the incentive program. Thus, adoption rates are different from those found in the mixed policy, even if the BMPs happen to be identical (see Table 26).

Target adoption rates for phosphorus BMPs are chosen on the basis of two factors: (1) some realistic levels we obtained after consulting agronomists of the respective regions and (2) the constraint of achieving the phosphorus target. While the realistic level is respected when enough choice of BMPs is available, we exceed it when no other BMPs are available to achieve the phosphorus target for that policy. This is the case of wooded riparian buffers on the Nicolet watershed. Even if the realistic adoption rate is around 60% for this region, we use 80% because the other available BMPs are already considered implemented at their realistic adoption levels or even more (80% for cover crops and 20% for intercropping or cover crops for corn; see Table 26).

TABLE 26 : BMP PORTFOLIOS BY POLICY FOR THE NICOLET WATERSHED

	Target adoption rates					Water quality target	Habitat target
	One-time payments	Annual payments	Mixed one-time/ annual payments	Auctions	Tradable permits		
Water quality BMPs							
Wooded riparian buffers	-	80%	-	-	-	0.036 mg TP/L	-
Grassy riparian buffers	60%	-	60%	50%	50%		
Cover crops for cereals	40%	80%	40%	94%	94%		
Intercropping	-	20%	-	-	-		
Reduced tillage and no-till	70%	-	70%	12%	12%		
Habitat BMPs							
Woodland preservation	3%	3%	3%	4.23%	-	-	1,165 ha
Wetland preservation	80%	80%	80%	-	-		
Removing lands prone to flooding from production	80%	80%	80%	-	-		

TABLE 27 : BMP PORTFOLIOS BY POLICY FOR THE LITTLE SASKATCHEWAN RIVER WATERSHED

	Target adoption rates					Water quality target	Habitat target
	One-time payments	Annual payments	Mixed one-time/ annual p.	Auctions	Tradable permits		
Water quality BMPs (the last three BMPs also have a habitat co-benefit)							
Cover crops for cereals	-	8%	-	1.8%	1.8%	0.050 mg TP/L	-
Manure storage	5%	-	6.03%	0.01%	0.01%		
Converting marginal farmland to wetlands	3%	3%	-	-	-		550 ha
Wooded riparian buffers	-	80%	-	-	-		
Grassy riparian buffers	80%	-	100%	100%	100%		

It is important to mention that both environmental objectives remain constant across policies in both watersheds: 0.036 mg TP/L and 1,165 ha of habitat for the Nicolet and respectively 0.05 mg TP/L and 550 ha of habitat for the Little Saskatchewan River. On the other hand, because the habitat objective varies in terms of its composition on both watersheds (e.g., 550 ha of wetlands for one-time and annual payments and 550 ha of terrestrial habitat for the other policies in the Little Saskatchewan River case), the monetary benefits associated also vary (see sections “0 Monetary Values of Benefits” and “6.2 Extrapolation of Benefits”).

3. COSTS OF SELECTED POLICIES

3.1. Private Costs of Adopting BMPs

This section examines the costs associated with implementing various BMPs to produce the priority EG&S.[35] To calculate the total private costs associated with adopting the BMPs, the various cost factors were categorized as follows:

1) the opportunity cost associated with the status quo, i.e., the current use of cultivable areas;
2) the investment cost associated with implementing an improvement (e.g., a riparian buffer zone);
3) the investment cost associated with purchasing specialized machinery;
4) the cost associated with periodic maintenance of the improvement and/or the specialized machinery;
5) the avoided costs (savings) and the additional income generated by the BMP in question.

This section describes the approach used to estimate the various cost factors and how these factors are included in estimating the private cost associated with the various BMPs. As a first step, the private costs of the BMPs are calculated on the basis of cost per unit ($/ha or $/animal unit). Then the total costs are calculated to determine the overall costs to be assumed by all farmers in the Nicolet and Little Saskatchewan River watersheds respectively if the steps defined in our policy scenarios are implemented.

3.1.1. Opportunity Cost Associated with the Current Use of Cultivable Areas

The vast majority of the BMPs studied are directly associated with the use of the cultivable areas. On the one hand, practices to improve the quality of wildlife habitats essentially redefine the usage of certain areas by re-establishing permanent plant cover along watercourses in wetlands or other fragile areas. These practices propose to reduce cropping in certain areas already used for agriculture. On the other hand, to be fully effective, practices that improve surface water quality by reducing phosphorus runoff require changes affecting the cropping system and the management of weeds and crop residue. These changes in the management of cultivable areas inevitably entail cost for the farming enterprise involved. Our objective here is to assess the opportunity cost associated with using a hectare of cultivable land for purposes other than agriculture.

[35] See above for more information on the analytical framework and definition of scenarios: priority EG&S choices, target levels for each EG&S, associated BMPs, and recognized effective policies for using the chosen BMPs.

We first studied the possibility of calculating the opportunity cost represented by potential contribution margins with crops included in a typical rotation. However, we quickly realized that this method would involve tremendous annual variations in the cost of this policy. In practice, net margins depend on a number of factors such as crop yield and commodity price, which can vary greatly from one production year to the next. The need to annually recalculate the payments made to producers would result in increasing program administration expenditures with the effect that public transaction costs would be accordingly higher.

We therefore opted for a much more stable indicator correlated to the loss in net revenue associated with the alternative use of cultivable lands: the rental rate for agricultural land. Technically, this rental price should reflect the profits that would be generated by working the land. In other words, the opportunity costs represented by typical use of the land should also be reflected in the rental price.

Calculating the Opportunity Cost Associated with Current Use of the Land

The opportunity cost of cultivating a hectare of land was therefore calculated taking into account the main crops in the Nicolet watershedand the land rental rate[36], according to the production cost data from Beauregard and Brunelle (2007). We therefore calculated a weighted average of farmland rental rate prices within the watershed (see appendix 11 for more details). The opportunity cost associated with the current use of cultivated areas in the Nicolet watershed thus comes to $164.10/ha/year.

Agricultural production in the Little Saskatchewan River watershed is primarily grains and oilseeds, as well as forage (see appendix 12 for more details on major crops in Little Saskatchewan River Watershed). Here, the opportunity cost is based on the compensation given by the ALUS Pilot project, which operates in a portion of the Little Saskatchewan River watershed. This program uses a compensation rate of $61.78 per hectare ($25.00 per acre, per year) for converting cropland in ecologically sensitive areas to non-economic use. The ALUS value is calculated according to land tenure costs and also accounts for the decreased risk that producers who adopt the policy will face, and the fact that the lands included may not be the most productive lands.

The following sections will study each BMP separately in terms of this opportunity cost, as well as the other private cost factors such as machinery investment, maintenance and avoided costs. It is important to note that the private cost associated with the BMPs already regulated by the Quebec government (limited livestock access and milkhouse wash-water disposal) will not be calculated or considered, given that these

[36] These land rental rate do not take into account the demand for land on which to spread manure.

costs are already covered by government compensation programs such as MAPAQ's Prime-Vert [green bonus] program.

3.1.2. Private Costs of BMPs Associated with Water Quality

Wooded Riparian Buffer Zones

In general, riparian buffer zones play an important role not only in protecting water and habitat quality but also in helping to regulate stream flows and stabilize banks. First and foremost, the planted species must be hardy, non-invasive and adapted in other respects. In some cases, species planted in riparian zones can provide a source of income to farmers.

In the case of the Nicolet watershed, a wooded buffer zone consisting of one row of willow and two rows of deciduous species, which forma strip approximately 10 metres wide, was chosen for analytical purposes. It provides direct advantages for farmers interested in producing biomass and fibre in the short term (3 years) and hardwood over the long term (40 years or more). These species were chosen in order to maximize farmers' short-term income (willow harvesting) and long-term income (hardwood lumber). At the same time, this three-stage vegetation model is recognized as having the greatest impact on biodiversity and bank stabilization, while continuing to exert a major effect on phosphorus levels on watercourses.

Quebec regulation stipulates that farming enterprises must maintain a stream bank buffer zone at least 3 metres wide.[37] Since the existing regulations do not specify whether such buffer zones must be wooded or grass-covered, it is assumed that farmers simply leave unplanted a 3-metre-wide strip along watercourses in order to meet regulatory requirements. The cost of expanding a buffer zone from 3 metres to 10 metres is essentially the same as the cost of going from 0 metres to 10 metres, since the current regulations do not require a strip containing shrubs or trees.

To calculate the total private cost of establishing a wooded buffer zone (purchase of trees, maintenance, etc.), use has been made of Version 7.5.2 of the tool developed jointly by CEPAF (Centre d'expertise sur les produits agroforestiers) and Agriculture and Agri-Food Canada (AAFC) to simulate the economic impact of agriforestry management measures. This simulation software was specifically designed to help landowners make decisions when establishing shelterbelts or wooded riparian buffer zones. Specifically, the model determines an actualized margin for a buffer zone between the cost of establishing and maintaining it over the years and the revenue it generates and the costs it prevents. To estimate these parameters, the model incorporates an inflation rate based on the consumer price index, an opportunity

[37] The regulatory width of buffer zones along ditches is 1 metre.

cost for borrowing money, and an actualization rate in order to calculate the margin in constant dollars for a given reference year. These rates are based on an analysis of Bank of Canada data from 1995 to 2005. The values associated with the various parameters have been inserted in the model for analysis purposes and are shown in appendix 13.

To maintain the buffer zones, we assume that trees that die during the first year of planting will be replaced, that weeds and grass around the young trees will be cut twice a year during the first five years of growth, and that a phytosanitary inspection of the trees will also be performed as part of this biannual maintenance process. As well, trees will be pruned for shaping each year from the second to the tenth year, and the more mature trees will be pruned until the trees reaching maturity are harvested. In terms of loss of cultivable land, the opportunity cost will be the one calculated above, taking into account farmland rental rate.

The total private costs associated with establishing a wooded buffer zone on a hectare of cultivable land vary greatly over time. (See appendix 13 for more details on private costs of establishing a wooded riparian buffer zone in Nicolet Watershed.) Specifically, the maintenance costs of wooded buffer zones decrease over time, while income from the wood starts in the third year and declines slightly thereafter, leading to declining total costs over time. This analysis was produced for only the first nine years of the buffer zone life cycle (which is approximately 40 years because of the deciduous species involved), since the proposed incentive programs last for nine years. After the first nine years, total costs continue to decline but overall net revenue is only achieved in the fortieth year, when the deciduous species mature and are harvested and sold. This revenue was not taken into account in calculating annual payments because it is too far in the future to convince producers to establish such zones. This revenue is simply seen as an additional incentive, estimated at $8,773 in year 40, to promote the adoption of this practice by more farmers. The private costs for establishing a 10-metre-wide wooded buffer zone in Nicolet Watershed are estimated at $7,848/ha.

Unlike in Quebec, there is no legislated requirement to protect riparian buffer zones in Manitoba. This suggests that the entire area of buffer zones should be included in incentive programs for setting aside these areas. The private costs of implementing riparian buffer zones predominantly come in the form of opportunity costs of removing land from production and the costs of establishing the buffer zone. Existing environmental incentive programs such as the Manitoba Environmental Farm Stewardship program cover the cost of seed, so it is included in this analysis.

Following the same hypothetical riparian zone BMP composition as is used in the Nicolet watershed (one row of willows and two rows of hardwoods) taken from version 7.5.2 of the *outil de simulation des* *impacts économiques et pratiques agroforestières*. In the Quebec case, estimates are made for establishment and maintenance costs. While ALUS does not explicitly compensate for these costs, they have been included in this analysis. Parameters for the calculation of private costs for riparian buffer zones in the Little Saskatchewan River watershed are included in appendix 13.

The projected costs for establishment of riparian buffer zones in one hectare of the Little Saskatchewan River watershed on an annual basis are approximately $2,875 in the first year. The total cost over a nine-year contract is $6,769.

Grassed Riparian Buffer Zones

For producers who decide to establish a buffer zone consisting solely of perennial grasses rather than shrubs or trees, the private cost associated with this BMP will differ somewhat from the costs associated with the management measure previously proposed. The private costs of establishing and maintaining a 10-metre-wide grassy riparian buffer zone have been calculated from data published by CRAAQ (Centre de référence en agriculture et agroalimentaire du Québec, 2007).

As in the case of establishing a wooded riparian buffer zone, calculations have been made of the cost of going from 0 metres of grassy strip to a width of 10 metres, as well as the cost of expanding from 3 metres to 10 metres in width, since it is assumed that producers already in compliance with Quebec regulations are simply leaving a 3-metre-wide strip along watercourses without crops and thus are not carrying out tillage operations there (to establish a grassy strip).

The establishment of a grassy riparian buffer zone 10 metres wide would thus cost $295.19/ha. In most cases, the establishment costs are eligible for grants from MAPAQ's Prime-Vert[38] program and the federal government's Greencover Canada program.[39] This combined financial assistance covers 70% of eligible expenditures up to a maximum of $20,000 per farm. The establishment cost would thus be reduced to $88.56/ha for the first 97 ha of buffer zone on a given farming enterprise, and this factor will be taken into account in calculating government compensation.

As previously mentioned, the opportunity cost associated with the current use of cultivable land is $164.1/ha (see Appendix 11).The maintenance cost of $10.40/ha must also be considered. Thus the total private cost of maintaining a 10-metre-wide grassy riparian buffer zone would be approximately $263/ha for the first year of establishment and approximately $174.5/ha for subsequent years. (See appendix 14 for

[38] The grant offered by the Prime-Vert program, which is conditional on carrying out a collective project, covers 20% of the initial investment cost.
[39] This program contributes 50% of the investment cost.

more information on private costs of establishing and maintaining a grassy riparian buffer zone in the Nicolet (East) watershed.)

It is important to note that our calculation assumes that no portion of the 10-metre buffer zone along watercourses would be commercially exploited. As a result, no revenue component has been considered for any possible sale of hay that could be cut from riparian buffer zones.

In the Little Saskatchewan River case, grassed riparian buffer zones can be accomplished by removing the lands around a waterway from agricultural production. There will be an establishment cost in the first year of $295 per ha. The ongoing costs to producers from implementing grassed riparian buffer zones will be $61.78/ha, the average opportunity costs of taking land out of production for the watershed.

Conservation Tillage (No-Till and Reduced Till)

The conservation practices described in this section are defined as soil management methods that help mitigate the negative impact of agriculture on the environment (CPVQ, 2000). Conservation tillage is a BMP which ensures that at least 30% of the soil surface remains covered by residues (stems, leaves or straw from the previous harvest) after seeding. The main tool used for the primary tillage of the soil is a chisel plough to aerate the soil. Then a sprayer equipped with heavy disks is used to continue chopping up the incorporated residues and apply the required fertilizer and herbicide. The investment in purchasing these two implements thus represents the main private cost associated with this practice. In fact, the level of investment required to purchase this equipment can vary greatly from one farming enterprise to the next, depending on their respective requirements.

Direct seeding is a practice that involves cultivating land without any tillage. This practice can require investment in suitable special machinery, especially a particular kind of seed drill, and can also vary from one farming enterprise to another. If a farmer decides to purchase a seed drill specially designed for direct seeding, this private cost is higher than if he were able to adapt existing equipment. Furthermore, adoption of this practice very much depends on the type of soil in the farm's fields. Loams and sandier soils are more suited to direct seeding than soils with higher clay content and structural deficiencies. The experts[40] we consulted in the Centre-du-Québec region agreed that the soils in the Nicolet watershed allow for adoption of this practice on a wider scale. However, the success of these various BMPs depends on adequate crop, weed and residue management.

[40] Vicky Villiard, agronomist with Club Durasol Inc., Drummondville, QC; and Guy Beauregard, agronomist, an independent consultant specializing in agricultural budgeting.

The total special machinery investment costs required by reduced till and no-till to be generally less than the cost of purchasing conventional corn and soya cultivation equipment (see appendix 15 for more details).

Some practices enable farmers to achieve higher contribution margins than they do with conventional methods. This is mainly due to the lower fuel costs implied in fewer passes with machinery and to lower mineral fertilizer costs. These benefits can be considered avoided private costs for the farming enterprise involved, but such avoided costs can vary from one practice to the next.

While the combined effect of conservation tillage and reduced fertilizer usage can result in avoided costs and thus profits, conservation tillage (or no-till) itself can constitute a practice that actually entails an additional private cost. Conversely, with the development of crop varieties suited to different soil conservation practices and more compatible with higher energy costs (fuel prices), these practices will tend more to avoid certain costs rather than generate additional costs (Gassman et al., 2006).

Given all the private cost factors involved in implementing the BMPs associated with soil conservation (investment cost, opportunity cost and avoided costs), the major cost remains the initial cost of purchasing specialized machinery. However, if these practices generate profits (for more information, see appendix 16), partly as a result of avoided costs, government assistance is only justified for part of this initial investment. In addition to an initial investment grant, technical support is recommended to help farmers overcome their lack of knowledge about and their initial mistrust of these two practices.

Cover Crops (for Cereals) and Intercrops (for Corn)

In general, these crops (cover crops or intercrops) are planted to provide protection during periods when commercial crops cannot be grown. This kind of plant coverage helps limit erosion and runoff. Further benefits of this practice include organic soil enrichment and improved soil structure. Establishing these crops often requires changes to the management of fields and equipment, particularly seed drills. However, the private cost associated with such changes primarily involves purchasing the seed to plant the cover crops and doing more field tillage.

Cover crops are planted after the close-row crops such as cereals. This is a crop planted after harvest, which remains in the field until seed bed preparation the following spring. It should be noted, however, that grasslands planted for an average of three years in the recommended rotation system also serve as cover crops and protect against erosion and runoff. This practice can also provide co-benefits in terms of longer-term soil fertility. However, these co-benefits are difficult to assess and have therefore not been taken into account in this analysis.

Intercropping involves sowing a crop between the rows of the main crop with a view to optimizing the use of space and ensuring constant soil coverage. It requires no additional soil preparation and lends itself well to producing commercial crops other than soya. If this method is adequately employed so that the intercrop does not inhibit the growth or harvesting of the main crop, it should not significantly lower yields (CPVQ, 2000).

Clearly, these practices do not require a major investment in the purchase of special machinery since they can be applied with conventional equipment. However, these methods must rely upon adequate soil and crop management.

According to the experts consulted[41], cover crops for cereals require some soil surface tillage, while the grain lost during harvest and natural re-growth is sufficient to provide adequate soil coverage for the fall and winter. For the Nicolet watershed, we have therefore only taken into account the cost of harrowing, which, according to the data from Beauregard and Brunelle (2004-2007), is approximately $4 per hectare per year.

In the case of intercrops, both the costs associated with purchasing the seed and with field operations (soil tillage) are taken into account. Since cereals and annual pulse crops are good intercrops, the partial budgets for timothy/alfalfa hay crops prepared by Guy Beauregard and André Brunelle of the MAPAQ Centre-du-Québec office have been used as the basis for calculating the cost of such planting. An average cost for the annual private cost of planting an intercrop on a hectare of cultivable land was established using the available budgets, i.e., those covering the period from 2004 to 2007. Our estimates thus show that the total private cost of adopting intercropping BMPs is $152/ha/year year (see appendix 17 for more details).

In both cases (cover crops and intercrops), a revenue component (sale of hay) is not considered because these crops are intended to be incorporated into the soil as green fertilizer.

Another advantage of this practice is the elimination of some fertilizer costs in subsequent years. This co-benefit is considered to offset the other costs (additional time in the field) that this practice entails. However, intercropping is a complex practice that requires careful monitoring, and the costs associated with this monitoring (technical help, training sessions, etc.) represent the pivotal issue in implementing this practice on a larger scale.

In the Little Saskatchewan River case, cover crops can reduce runoff and erosion and reduce nutrient losses during fallow periods. In Quebec, a cover crop is included in the rotation after the third year in a

[41] The experts consulted on the subject are H. Moore and A. Vanasse.

five-year rotation. In Manitoba, fall rye is the most common cover crop, but wheat, barley and oats are also used (MAFRI, 2006). The Manitoba Farm Stewardship program subsidizes the costs of equipment and seeds for the establishment of non-economic cover crops. The frequency with which cover crops are included in rotations depends to a large extent on the type of soil. This analysis looks at the use of a non-economic cover crop as green manure. The estimated private cost of this practice is estimated to be the cost of seeds and labour for a crop of fall rye: $27.80 per ha per year.

Manure Storage (for Little Saskatchewan River Watershed only)

In Manitoba, manure is typically stored in clay-lined earthen pits. The cost of these facilities comes entirely as initial investment, since engineering design must be carried out and heavy equipment is required for their construction. Manitoba 2005 budget guidelines for a 120-cow dairy operation peg the cost of a manure storage facility sized for one year of storage at $60,000 (Blawat et al., 2005). This is equivalent to $63,654 in 2007 dollars. This works out to a capital cost of $1.45 for each day of storage capacity per head.

3.1.3. Private Costs of BMPs Associated with Habitat

Wetland and Woodland Conservation

Mainly because they are so fertile, a number of wetlands and woodlands across this country are cleared and planted every year. The BMP associated with this EG&S generally involves preserving designated ecological features such as riparian zones, wetlands, permanent plant cover in fragile zones, and woodlands in farming areas, since these environments are all crucial for wildlife habitat and natural water filtration.

The private costs on which to base the compensation per hectare that a farmer would receive for implementing this BMP corresponds to the opportunity cost associated with the current use of the land. This cost was previously calculated on the basis of the land rental rate in this region, which, according to the partial budgets prepared by Guy Beauregard and André Brunelle, varies between $120 ha/year and $240/ha/year. Although this opportunity cost is affected by the government bodies that regularly intervene to support producer incomes and/or cover a major part of production-related risks through crop insurance programs, the lease price will be used here for analytical purposes. This decision was made in light of the fact that the Conservation Reserve Program (CRP) in the United States uses land rental rate as opportunity costs when calculating this type of compensation, even though there is substantial government intervention in agricultural markets in that country.

In fact, the lower land rental rate of $120/ha rather than the weighted average of land rental rate within the watershed (164.10/ha) has been taken as the opportunity cost of conserving a wildlife habitat that would otherwise be converted into agricultural land. This decision stems from the fact that several lands that would qualify for compensation are not always suited for such conversion.

In view of the investment required to develop a wetland into a cultivable and productive area (drainage, etc.), we estimate that 75% of the calculated opportunity cost, i.e., $90/ha/year, represents the amount that a producer should be ready to accept for a lifetime agreement not to convert wetlands into croplands. In the case of the woodlands, we estimate that 50% of the calculated opportunity cost ($60/ha/year) is sufficient, given the additional income that can be derived from trees through activities such as maple sugar production and the sale of firewood.

In the Little Saskatchewan River watershed, wetlands qualify under several existing environmental incentive programs, such as ALUS, Greencover Canada, and the Canada-Manitoba environmental farm stewardship program. ALUS pays a rate of $34.59 per hectare ($15 per acre) of existing wetlands annually and $59.31 ($25 per acre) for land taken out of production. Greencover Canada provides incentives for verified permanent cover at a rate of $247.10 per hectare ($100 per acre) if native species are used, and $111.19 per hectare ($45 per acre) if tame forage is used. The cost of converting marginal farm land to wetlands is estimated to be the opportunity cost of removing the land from production, $61.78 per year[42].

Restoring Agricultural Floodplains (Nicolet East Watershed)

This practice involves restoring agricultural floodplains to their natural state so that they can serve as habitat for various wildlife species. Compensation currently exists for this practice under the Greencover Canada Program as part of AAFC's contribution to the country's Agricultural Policy Framework (2003-2008). This program's Land Conversion component provides financial assistance to offset part of the cost of converting ecologically vulnerable land from annual cropping to permanent plant cover.

This incentive is provided in the form of a one-time payment of $100/acre ($247.10/ha) to plant indigenous forage crops. This payment is made after an agreement has been signed between the farmer and the government ensuring maintenance of perennial cover plants on the land in question for a period of 10 years. The amount of a one-time payment spread over this period of time would thus represent periodic compensation of approximately $25/ha/year.

[42] See section 3.1.1 : Calculating the Opportunity Cost Associated with Current Use of Land.

Given current land rental rates and sale prices in eastern Canada, this level of compensation is clearly not enough to persuade farmers in this region to stop planting on floodplain lands. Instead, the previously calculated current land-use opportunity cost of $164.10/ha/year would represent an adequate level of compensation. This compensation would therefore be considered sufficient to compensate all the private costs associated with taking floodplain land out of agricultural production and restoring it to wildlife habitat (seeding wild plant species, making other appropriate improvements, etc.).

The next table summarizes private costs of different BMPs in the Nicolet and Little Saskatchewan River watersheds.

TABLE 28 : SUMMARY OF PRIVATE COSTS OF BMPS FOR NICOLET AND LITTLE SASKATCHEWAN RIVER WATERSHEDS

EG&S	BMP	Nicolet	Little Saskatchewan River
Water Quality	Current use of cultivated lands($/ha*year)	164.1	61.78
	Wooded Riparian Buffer Zones ($/ha for 9 years)	7,848	6,769
	Grassy riparian buffer zone ($/ha*year)	263 (for the 1st year)	295 (for the 1st year)
		174.5 (for subsequent years)	61.78 (for subsequent years)
	Intercropping ($/ha*year)	152	
	Cover crops ($/ha*year)	4 (harrowing only)	27.8 (harrowing and seeds)
	Manure Storage ($/head*day)		1.453
Habitat	Wetland conservation ($/ha*year)	90	61.78
	Woodland conservation ($/ha*year)	60	61.78
	Restoring Agricultural Floodplains ($/ha*year)	164.1	

Main differences between the Nicolet and Little Saskatchewan River private costs are found in producers' opportunity costs for not cultivating lands (164.10 $/ha/year in Nicolet and 61.78 $/ha/year for Little Saskatchewan River).

3.1.4. Private Transaction Costs

According to the OECD (2007a), producers' private transaction costs consist of the opportunity cost of the time spent in completing forms, travelling, and verifying requirement compliance and the value of equipment purchased and services provided (stamps and advisory services). According to the same source, such costs can only be estimated by the farmers themselves and indicated in questionnaires or interview reports.

To the best of our knowledge, there are no studies on the private transaction costs engendered by agro-environmental programs in North America. However, two studies have estimated these costs for Europe. Specifically, the private transaction costs engendered by the Swiss direct payment system are estimated in the OECD study (OECD, 2007a) at more than two thirds of total transaction costs in the case of the Grisons canton and more than three quarters in the case of the Zurich canton. More than half of these private transaction costs involve keeping records and filling out forms. The same study estimated transaction costs in the United States' Conservation Reserve Program (CRP), but since no information was collected on private transaction costs in this program, this aspect was not estimated.

The second study on private transaction costs was conducted by Mettepenningen et al. (Mettepenningen et al., 2007) as part of the European Union project, "Integrated tools to design and implement agro-environmental schemes" (ITAES). Involving a survey and follow-up of farmers in several EU countries (France, Germany, Czech Republic, Italy, United Kingdom, Belgium, the Netherlands and Ireland), this study concluded that the share of private costs engendered by BMPs ("agro-environmental schemes") is 14% on average, but with very substantial variations ranging from 0.2% to 65% from one country to the next. Given that this considerable variability among countries is probably due to very different approaches to administrative requirements, the use of an average of 14% for the programs covered by this study is not warranted.

The level of private transaction costs is very dependent on the administrative details of each program: the level of information needed to determine eligibility, the follow-up required once the BMP in question has been adopted, and so on. Transferring the results from the other studies demands the existence of basic similarities at this level, which is not clear in the case of the two studies available. Furthermore, differentiating private transaction costs by program type (one-time or annual payment) is not possible when both these studies provide figures for all agro-environmental programs combined.

3.2. Public Costs of Policy Implementation

3.2.1. Payments

The following subsections present detailed calculations of the disbursement amounts under policies using annual payments, one-time payments, a mixed policy of one-time payments and annual payments or marketplace instruments (auctions and tradable permits). These payments take into account the opportunity cost associated with current land use, net losses associated with implementing BMPs, and the percentage share of capital investment subsidized by other programs. It should be mentioned that we do not consider the payments from other programs that are saved because certain agricultural lands are withdrawn from production (e.g., Quebec Farm Income Stabilization Insurance Program, Canadian Agricultural Income Stabilization). As a consequence, payment levels are somewhat over-estimated, but because this over-estimation applies to all policies considered, it does not affect the comparison of policy efficiency.

In the case of annual and one-time payment, the calculations are first made by unit of surface area (ha) or by farm, and then aggregated for the entire watershed concerned. In the case of auction and tradable permit policies, we feel that these are effective market-based systems which ensure that the most effective individual practices are implemented first. Since the cost of implementing the same practice can differ from one producer to another, the aim is to determine how many measures associated with a particular practice can be implemented for a given payment.[43]

Moreover, two actualisation rates are used in this study. The first one (3%) is used to actualize the multi-year private costs incurred by producers because this rate has a major impact on their decision whether or not to adopt the BMPs. The second rate (6%) corresponds to the actualization rate generally used to work out the amounts awarded under public policies (Montmarquette and Scott, 2007).

The following sections present detailed information on how payments have been calculated for each practice and policy studied, as well as the totals for our two representative watersheds, Nicolet and Little Saskatchewan River.[44]

3.2.1.1. One-Time Payments

The aim of a one-time payment policy is to encourage implementation of certain BMPs through a single payment to help cover all the net losses incurred by farmers in meeting their contractual commitments in this regard.

The BMPs that have been included in the one-time payment policy in the Nicolet case are: grassy riparian buffer zones, conservation tillage using a chisel plough, direct seeding, cover crops for cereals, maintaining woodlands and wetlands in agricultural areas, and crop reduction on agricultural floodplains.

The one-time payment portfolio for the Little Saskatchewan River watershed consists of three BMPs: grassed riparian buffer zones with no annual maintenance, wetlands, and livestock manure storage. It is assumed that implementation of the BMPs would reach target levels only after five years. For each of the first five years the adoption rate is assumed to be 1/5 of the total target adoption rate for each BMP. Therefore all one-time payments would be made by the end of the fifth year.

[43] For example, if the cost of excluding one kilogram of phosphorus is estimated at $50, how many excluded kilograms will be sold by producers after implementing cover crops, riparian buffer zones and intercropping?
[44] In the Little Saskatchewan River case, habitat creation is considered as a co-benefit resulting from BMP implementation.

It is important to bear in mind that in the case of maintaining woodlands and wetlands in agricultural areas, one-time payments are equivalent to a conservation servitude for the life of the contract (nine years).

Grassed Riparian Buffer Zones

In the Nicolet sub-watershed, the overall payment comes to $1,547 (see appendix 18 for more details) to maintain a hectare of grassy riparian buffer zone in a wild state for nine years. This amount includes the grant awarded for plant-cover regeneration on the land concerned (which corresponds to 50%[45] of the establishment costs of the riparian buffer zone) and the total actualized land opportunity costs.

In the Little Saskatchewan River watershed, the riparian buffer zone BMP covers 50% of the establishment costs, and opportunity costs of removing land from agricultural production. The opportunity cost is based on the yearly land rental rate of $61.77 per ha. In the Little Saskatchewan River watershed case, the total one-time payment for one hectare of grassed riparian buffer zone is $545 (see appendix 18). This is almost three times lower than the payment for the same BMP in the Nicolet sub-watershed, as the opportunity costs (based on the rental price of the land) are 2.5 times higher in the Nicolet (East) watershed.

No-Till and Reduced Tillage (for the Nicolet only)

In the Centre-du-Québec region, the incentive offered to producers to adopt direct seeding or conservation tillage using a chisel plough consists of a grant of 30% of the cost of specialized equipment up to $15,000 per farm, as well as two years of funding to cover technical assistance from an agronomist. Thus, with an estimated investment of $50,000 for direct seeding and an estimated $550 for annual follow-up by an agri-environmental advisory club, the total payments come to $15,550 for the first year and $550 for the second. Even though conservation tillage requires a higher investment (e.g., for a chisel plough and other tools) than direct seeding, the two payments are identical because of the investment funding limit of $15,000 (see appendix 18).

Cover Crops (for Cereals) (for the Nicolet only)

Since this practice does not entail capital investment or major annual expenditures but its implementation requires specific expertise, the proposed incentive is to pay for the technical assistance required for one year. The time span for this incentive is shorter than in the case of direct seeding and conservation tillage

[45] Based on the Greencover Canada Program.

because the practice is easier to integrate into the conventional production system. As specified for reduced tillage and no-till, the grant for technical assistance is estimated at $550 per year per farm for the Nicolet sub-watershed.

Maintaining Woodlands and Wetlands in Agricultural Areas (for the Nicolet only)

The weighted average of land rental rates in the Nicolet sub-watershed is $164.10/ha. However, the payment for each hectare of woodland or wetland left in a wild state is estimated on the basis of the least expensive land rental rate ($120/ha/year in the Nicolet sub-watershed) reduced by 50% for woodland and by 75% for wetland. The lower lease price ($120/ha) is used because not all agricultural land or other environments qualifying for compensation are suitable for conversion to agricultural activity. Furthermore, the difference between the amounts allocated for woodland and wetland is due to the potential income that can be generated from forestry operations. The annual opportunity costs associated with woodland and wetland conservation within the Nicolet sub-watershed are thus estimated at $60/ha and $90/ha respectively,[46] and the one-time payments to cover the opportunity cost associated with current use of the land over a nine-year period for these two practices come to $481/ha and $722/ha respectively.

Maintaining (Nicolet) or Converting (Little Saskatchewan River) Marginal Lands to Wetlands

The payment for agricultural floodplains compensates farmers for the opportunity cost associated with land use. After actualization, a one-time payment of $1,316 for withdrawing one hectare of agricultural floodplain in the Nicolet sub-watershed is obtained.

In the Little Saskatchewan River watershed, the one-time payment for converting marginal lands to wetlands is based on the lease rate for this land of $61.77 per year. The total actualized payments for one hectare of wetland for a nine-year contract is $397.13.

[46] These amounts are approximately twice as high as those offered by the Manitoba's Agricultural Land Use Services (ALUS) program pilot project ($37/ha/year for woodlands and wetlands in a wild state) and even higher than the maximums offered by the federal Greencover Canada Program (a maximum of $247/ha for 10 years of conservation).

Manure Storage (for the Little Saskatchewan River only)

The one-time payment for manure storage covers 30% of the cost of constructing an earthen manure storage facility in the Little Saskatchewan River watershed. The total payments for manure storage come to $0.48 per head for each day of storage capacity (in 2007 dollars).

Total One-Time Payments for the Entire Watersheds

The same approach is used here for calculating payments per hectare or per farm, but the units are then multiplied by the number of hectares or farms in the watershed.

Farmers make a commitment for nine years, but the payment will be made only once at the start of the program. It is assumed that the target adoption rates will be achieved by the fifth year, which implies that new producers will not join the program from the sixth year on. In the case of one-time payments, this also implies that payments will not be made from the sixth year on, except for direct seeding and conservation tillage, for which technical assistance lasts two years.

Table 29 shows total one-time payments for the Nicolet sub-watershed. The data on the number of farms and number of ha under cultivation come from the 2006 Census of Agriculture and are totalled for the watershed using the list of municipalities that have more than 50% of their respective land areas falling within the watershed.

In the case of cover crops, the amount paid in the first year is lower than the amount in subsequent years, despite the fact that the adoption rate is much higher in the first year than in the following years (20% compared with 5% in each subsequent year). This is because farmers who adopt the practice before the program is set up are not considered. In other words, the adoption rate in the first year is only an additional 2%, whereas it is 5% in the following years.

TABLE 29 : AMOUNTS OF ONE-TIME PAYMENTS MADE IN THE NICOLET SUB-WATERSHED (BY YEAR AND BY BMP)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	TOTAL
Grassy riparian buffers							
Target adoption rate[47]	20%	30%	40%	50%	60%		
Payments ($)	125,683	62,841	62,841	62,841	62,841		377,049
Actualized payments ($)	**125,683**	**59,284**	**55,929**	**52,763**	**49,776**	**0 $**	**343,435**
No-till and reduced till							
Target adoption rate[48]	50%	55%	60%	65%	70%		
Payments ($)	328,883	194,345	189,175	189,175	189,175	6,463	1,097,215
Actualized payments ($)	**328,883**	**183,344**	**168,365**	**158,835**	**149,844**	**4,829**	**994,100**
Winter cover crops for cereals							
Target adoption rate[49]	20%	25%	30%	35%	40%		
Payments ($)	1,936	4,840	4,840	4,840	4,840		21,296
Actualized payments ($)	**1,936**	**4,566**	**4,308**	**4,064**	**3,834**	**0**	**18,707**
ONE-TIME PAYMENTS FOR PHOSPHORUS (actualized payments, $**)**	**456,501**	**247,195**	**228,601**	**215,662**	**203,454**	**4,829**	**1,356,242**
Maintaining woodlands in agricultural areas							
Target adoption rate	1%	1,5%	2%	2,5%	3%		
Payments ($)	132,378	66,191	66,191	66,191	66,191		397,143
Actualized payments ($)	**132,378**	**62,445**	**58,910**	**55,576**	**52,430**	**0**	**361,738**
Maintaining wetlands in agricultural areas							
Target adoption rate	40%	50%	60%	70%	80%		
Payments ($)	111,748	27,937	27,937	27,937	27,937		223,495
Actualized payments ($)	**111,748**	**26,356**	**24,864**	**23,456**	**22,129**	**0**	**208,552**
Reduced cropping in agricultural floodplains							
Target adoption rate	40%	50%	60%	70%	80%		
Payments ($)	19,514	4,879	4,879	4,879	4,879		39,028
Actualized payments ($)	**19,514**	**4,602**	**4,342**	**4,096**	**3,864**	**0**	**36,419**
ONE-TIME PAYMENTS FOR HABITAT (actualized payments, $**)**	**263,640**	**93,403**	**88,116**	**83,128**	**78,423**	**0**	**606,709**
ONE-TIME PAYMENTS FOR PHOSPHORUS & HABITAT (actualized payments, $)	**720,141**	**340,597**	**316,717**	**298,790**	**281,877**	**4,829**	**1,962,951**

[47] *Adoption rate in 2003: unknown but probably very low.*
[48] *Adoption rate in 2003: 41%.*
[49] *Adoption rate in 2006: 18%.*

For the Nicolet sub-watershed, the total of one-time payments associated with this policy come to a actualized value of $1.962 million, of which $1.356 million is for lowering phosphorus levels in watercourses to achieve the target environmental objective (0.036 mg/l TP) and $0.606 million for maintaining 1,165 ha of habitat (wetland and woodland).

As in the Quebec case, it is assumed that it will take five years in order to reach the desired rate of BMP implementation in the Little Saskatchewan River watershed. It is also assumed that BMP implementation will occur in equal increments over the five years. Our analysis indicates that the cost at which BMPs can achieve reductions in phosphorous loadings can vary greatly. In this analysis, preference is given to the BMPs that can achieve P reduction most economically, as determined by our calculations. It is assumed that a maximum feasible implementation rate for riparian buffer zones would be 80%. Riparian buffer zones offer the most economical means of achieving P load reduction in both the one-time and annual payment policies (see Table 30). Wetlands appear to be the most expensive means of achieving P reductions for both policies in this analysis; however they have the added benefit of increasing wildlife habitat. For this reason it was decided to use an implementation rate of 3% of agricultural land for conversion to wetlands. A higher implementation rate for wetlands is probably not feasible since this BMP is likely to be implemented only in the most marginal land.

Under this simulation, 80% (443 km) of the riverbanks under cultivation in the watershed would become buffer zones for a P loading reduction benefit of 11.9 tonnes per year and a wildlife habitat benefit of 443 ha. When implemented over five years, the total actualized cost of these payments is $227,594.

Our analysis assumes that 3% of land presently under agricultural production will be converted to wetlands, for a reduction in P loading of 5 tonnes per year. The total cost of these payments actualized over a five year implementation period is $2.06 million. Even if the habitat increase due to this BMP is of 5,505 ha, only 550 ha are considered for estimations of benefits and costs linked to habitat in order to respect the habitat objective.

We estimate that one-time payments totalling $265,344 be constructed to handle manure for 200 days of storage for 2,900 head of cattle. These facilities could include collection basins to store runoff for cattle over-wintering facilities, a solids settling basin, or earthen manure storage facilities. The P loading reduction benefit would be 6.4 tonnes per year. While these payments could handle 200 days of storage for 2,900 heads, other combinations would have the same effect. For example, storing the waste of 5,800 head for 100 days would yield the same benefit.

Table 30 shows the aggregated one-time payments for the Little Saskatchewan River watershed. All payments listed in the table are for water quality, although some BMPs analysed have habitat co-benefits. Unlike the Nicolet case, these habitat co-benefits are not included in the total because they are already factored into the payments for water quality.

TABLE 30 : ONE TIME PAYMENTS PAID BY THE GOVERNMENT AS PART OF A BMP INCENTIVE POLICY FOR THE LITTLE SASKATCHEWAN RIVER WATERSHED[50]

	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Grassed Riparian Buffer Zones						
Target adoption rate	16.00%	32.00%	48.00%	64.00%	80.00%	
Payments ($)	48,249	48,249	48,249	48,249	48,249	
Actualized payments ($) (A)	**48,249**	**46,843**	**45,479**	**44,154**	**42,868**	**227,594**
Wetlands						
Target adoption rate	0.60%	1.20%	1.80%	2.40%	3.00%	
Payments ($)	437,209	437,209	437,209	437,209	437,209	
Actualized payments ($) (B)	**437,209**	**424,475**	**412,111**	**400,108**	**388,455**	**2,062,358**
Manure Storage						
Target adoption rate	1.00%	2.00%	3.00%	4.00%	5.00%	
Payments ($)	56,251	56,251	56,251	56,251	56,251	
Actualized payments ($) (C)	**56,251**	**54,613**	**53,022**	**51,478**	**49,979**	**265,344**
ONE-TIME PAYMENTS FOR PHOSPHORUS (actualized) (A+B+C) (include payments for habitat)	**541,709**	**525,931**	**510,613**	**495,741**	**481,302**	**2,555,295**
ONE-TIME PAYMENTS FOR HABITAT (actualized)[51] (10%*B)	**43,720**	**42,447**	**41,211**	**40,010**	**38,845**	**206,235**
ONE-TIME PAYMENTS FOR PHOSPHORUS & HABITAT (actualized) (A+B+C)	**541,709**	**525,931**	**510,613**	**495,741**	**481,302**	**2,555,295**

[50] We use a 6% actualization rate.
[51] The payments for habitat are considered to be equal to 10% of the payments for wetlands since the 550 ha of habitat represents 10% of the total 5,505 ha of wetlands restored through this practice.

In this case, the environmental benefit targets of a 75% reduction in phosphorous concentrations, and maintenance and enhancement of existing wildlife habitat can be achieved with $2.55 million in incentive payments through a one-time payment policy.

3.2.1.2. Annual Payments

An annual payment policy involves giving financial compensation to farmers participating in the program to cover all the net annual expenses caused by implementing BMPs in their operations.

The BMPs that make up the annual payment policy portfolio in the Nicolet case are wooded riparian buffer zones, cover crops for cereals, intercropping, maintaining woodland and wetland in agricultural areas, and reduced cropping on agricultural floodplains.

The annual payment portfolio for the Little Saskatchewan River watershed consists of wooded riparian buffer zones where annual maintenance is required, non-economic winter cover crops, and the conversion of marginal farmland to wetland. As with one time payments, it is assumed that BMP implementation to target levels will occur in equal increments of 1/5 of target adoption rate per year for five years. Since contracts will be for three years and renewable two times, the final payments would be made nine years after the final lands enter the program, for a total of 13 years.

Wooded Riparian Buffer Zones

Unlike grassy riparian buffer zones, wooded riparian buffer zones require a fair amount of periodic maintenance (see appendix 19 for more details). For the Nicolet sub-watershed, the components of the annual payment are, as follows: the opportunity cost associated with the loss of cultivable land, the maintenance cost of the buffer zone, and the income from the sale of lumber. In addition, the first year's payment includes a grant covering 50% of the initial investment.[52]

Owners of one hectare of wooded riparian buffer zone inside the Nicolet sub-watershed will thus receive $6,872 over nine years (see Appendix 19), a much larger sum than that awarded for grassy strips without maintenance ($1,547).

In the Little Saskatchewan River watershed, the BMP annual payments for riparian buffer zones are calculated on the basis of the opportunity costs, the annual maintenance costs, and 50% of the cost of vegetation establishment. The estimated income from harvesting wood is subtracted from these payments.

[52] Measure based on the Greencover Canada Program.

The total annual payment for 1 hectare of wooded riparian buffer zones is here estimated at $6,769 (see Appendix 19).

Intercropping (for the Nicolet East only)

More than cover crops for cereals, this practice lends itself to an annual payment policy because it involves recurring costs year after year and because a certain degree of expertise is required of the farmers using this practice. To encourage producers to plant intercrops, regular guidance is needed as well as compensation for the cost of purchasing seed and ploughing the land, which are the highest costs involved in this practice. Payment is made every year, but technical assistance is only provided for the first two years of the program. To calculate the payments, we use Statistics Canada (Statistics Canada, 2007) data on the average size of farms growing corn in the Nicolet sub-watershed (51 ha).

The payment per hectare for intercropping in the Nicolet sub-watershed is $1,394 (see Appendix 19).

Cover Crops for Cereals

The annual payment for cover crops on the Nicolet sub-watershed is designed to cover the cost of labour during 9 years and the cost of technical assistance for one year. To calculate the payments, we use Statistics Canada (Statistics Canada, 2007) data on the average size of farms growing cereals in the Nicolet sub-watershed (21.25 ha). The payment per hectare for cover crops for cereals in the Nicolet sub-watershed is $62 (see Appendix 19).

In the Little Saskatchewan River watershed case, the annual payment for cover crops is designed to cover half the cost of seed for a non-economic crop. The cost of seeding one hectare of land with fall rye is approximately $27.80. At 50% of costs; this amounts to an incentive payment of $13.90 per hectare (see Appendix 19).

Maintaining Woodland and Wetland in Agricultural Areas (for Nicolet East only)

In the Nicolet sub-watershed, the annual payments associated with maintaining woodland in agricultural areas corresponds to 50% of the annual opportunity cost, which results in payments over nine years for woodlands of $540/ha. The annual payments associated with maintaining wetland corresponds to 75% of the annual opportunity cost, resulting in payments over nine years for wetlands of $810/ha.

Converting Marginal Lands to Wetlands

The level of payments to take agricultural floodplain land out of crop production corresponds to the opportunity cost related to the land rental rate, which has been estimated at $164/ha for the Centre-du-Québec region. Total payments to reduce cropping on agricultural floodplains within the Nicolet sub-watershed for the entire contract period (nine years) thus come to $1,477/ha.

The annual payment for converting marginal lands to wetlands in the Little Saskatchewan River watershed is based on the ALUS Pilot project's payment of $61.77 per hectare per year (with a present value of $397 per hectare for the whole nine year contract).

Total Annual Payments for the Entire Watershed

To determine total annual payments for the entire watershed, we use the same approach as for one-time payments. The hypothesis that the target adoption rates are achieved in the fifth year implies, as in the case of one-time payments, that no new producers join the program from the sixth year on. Farmers can enrol in the program between the first and fifth years and can sign up for a maximum of three three-year contracts, regardless of the year they join. This implies that for up to five years after the program closes, payments will continue to be made to producers who joined the program in the last year it was possible to do so.

The following table shows the annual payments for the reduction of phosphorus levels in watercourses and the preservation of habitat within the Nicolet sub-watershed.

TABLE 31 : ANNUAL PAYMENTS MADE BY THE GOVERNMENT FOR THE NICOLET SUB-WATERSHED (BY YEAR AND BY BMP)

BMP	Target Adoption Rate	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	TOTAL
Wooded riparian buffer zones	40%	415,705	176,649	154,349	153,903	153,903	93,470	93,247	93,024	93,024					1,427,278
	50%		103,926	44,162	38,587	38,476	23,368	23,312	23,312	23,256	*23,256*				341,656
	60%			103,926	44,162	38,587	38,476	23,368	23,312	23,312	*23,256*	*23,256*			341,656
	70%				103,926	44,162	38,587	38,476	23,368	23,312	*23,312*	*23,256*	*23,256*		341,656
	80%					103,926	44,162	38,587	38,476	23,368	*23,312*	*23,312*	*23,256*	*23,256*	341,656
PAYMENTS ($) (actualized)	**(A)**	**415,705**	**264,694**	**269,169**	**285,957**	**300,247**	**177,895**	**152,969**	**134,003**	**116,869**	**55,127**	**38,989**	**24,502**	**11,558**	**2,247,686**
Intercrops	2.50%	48,934	48,934	45,703	45,703	45,703	45,703	45,703	45,703	45,703					417,786
	5%		48,934	48,934	45,703	45,703	45,703	45,703	45,703	45,703	45,703				417,786
	10%			97,868	97,868	91,405	91,405	91,405	91,405	91,405	91,405	91,405			835,572
	15%				97,868	97,868	91,405	91,405	91,405	91,405	91,405	91,405	91,405		835,572
	20%					97,868	97,868	91,405	91,405	91,405	91,405	91,405	91,405	91,405	835,572
PAYMENTS ($) (actualized)	**(B)**	**48,934**	**92,328**	**171,328**	**241,089**	**299,844**	**278,042**	**257,748**	**243,159**	**229,395**	**189,359**	**153,121**	**96,302**	**45,426**	**2,346,074**
Cover crops for cereals	18% + 2%	2,235	299	299	299	299	299	299	299	299					4,629
	35%		16,764	2,244	2,244	2,244	2,244	2,244	2,244	2,244	2,244				34,716
	50%			16,764	2,244	2,244	2,244	2,244	2,244	2,244	2,244	2,244			34,716
	65%				16,764	2,244	2,244	2,244	2,244	2,244	2,244	2,244	2,244		34,716
	80%					16,764	2,244	2,244	2,244	2,244	2,244	2,244	2,244	2,244	34,716
PAYMENTS ($) (actualized)	**(C)**	**2,235**	**16,097**	**17,183**	**18,095**	**18,848**	**6,931**	**6,539**	**6,169**	**5,819**	**5,313**	**3,759**	**2,364**	**1,115**	**110,468**
PAYMENTS FOR PHOSPHORUS ($) (actualized)	**(A)+(B)+(C)**	**466,875**	**373,120**	**457,680**	**545,141**	**618,939**	**462,868**	**417,256**	**383,331**	**352,084**	**249,799**	**195,869**	**123,169**	**58,098**	**4,704,228**

BMP	Target Adoption Rate	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	TOTAL
Maintaining woodlands in agricultural areas	1%	16,507	16,507	16,507	16,507	16,507	16,507	16,507	16,507	16,507					148,559
	1.5%		8,254	8,254	8,254	8,254	8,254	8,254	8,254	8,254	*8,254*				74,282
	2.0%			8,254	8,254	8,254	8,254	8,254	8,254	8,254	*8,254*	*8,254*			74,282
	2.5%				8,254	8,254	8,254	8,254	8,254	8,254	*8,254*	*8,254*	*8,254*		74,282
	3.0%					8,254	8,254	8,254	8,254	8,254	*8,254*	*8,254*	*8,254*	*8,254*	74,282
PAYMENTS ($) (actualized)	**(D)**	**16,507**	**23,359**	**29,382**	**34,649**	**39,225**	**37,005**	**34,910**	**32,934**	**31,070**	**19,541**	**13,826**	**8,696**	**4,102**	**325,206**
Maintaining wetlands in agricultural areas	40%	13,934	13,934	13,934	13,934	13,934	13,934	13,934	13,934	13,934					125,407
	50%		3,484	3,484	3,484	3,484	3,484	3,484	3,484	3,484	*3,484*				31,352
	60%			3,484	3,484	3,484	3,484	3,484	3,484	3,484	*3,484*	*3,484*			31,352
	70%				3,484	3,484	3,484	3,484	3,484	3,484	*3,484*	*3,484*	*3,484*		31,352
	80%					3,484	3,484	3,484	3,484	3,484	*3,484*	*3,484*	*3,484*	*3,484*	31,352
PAYMENTS ($) (actualized)	**(E)**	**13,934**	**16,432**	**18,602**	**20,474**	**22,074**	**20,825**	**19,646**	**18,534**	**17,485**	**8,248**	**5,836**	**3,670**	**1,731**	**187,491**
Reduced cropping in agricultural floodplains	40%	2,433	2,433	2,433	2,433	2,433	2,433	2,433	2,433	2,433					21,899
	50%		608	608	608	608	608	608	608	608	*608*				5,475
	60%			608	608	608	608	608	608	608	*608*	*608*			5,475
	70%				608	608	608	608	608	608	*608*	*608*	*608*		5,475
	80%					608	608	608	608	608	*608*	*608*	*608*	*608*	5,475
PAYMENTS ($) (actualized)	**(E)**	**2,433**	**2,869**	**3,248**	**3,575**	**3,855**	**3,637**	**3,431**	**3,237**	**3,053**	**1,440**	**1,019**	**641**	**302**	**32,741**
PAYMENTS FOR HABITAT ($) (actualized)	**(D)+(E)+(F)**	**32,874**	**42,660**	**51,233**	**58,698**	**65,154**	**61,466**	**57,987**	**54,705**	**51,608**	**29,229**	**20,681**	**13,007**	**6,135**	**545,438**

PAYMENTS FOR PHOSPHORUS & HABITAT ($) (actualized)	**(A)+(B)+(C)+ (D)+(E)+(F)**	**499,749**	**415,779**	**508,913**	**603,839**	**684,093**	**524,335**	**475,244**	**438,036**	**403,692**	**279,028**	**216,550**	**136,175**	**64,234**	**5,249,666**

Total annual payments within the Nicolet sub-watershed come to an actualized amount of $5.249 million: $4.704 million to achieve the target phosphorus level in watercourses and $0.545 million to preserve 1,165 ha of wetland and woodland.

Total incentive payments in the Little Saskatchewan River watershed are presented in Table 32. In this table, all payments are for water quality. However some BMPs analysed have habitat co-benefits. Unlike the Nicolet case, these habitat co-benefits are not included in the total because they are already factored into the payments for water quality.

TABLE 32 : ANNUAL PAYMENTS PAID BY THE GOVERNMENT AS PART OF AN ANNUAL PAYMENT BMP INCENTIVE POLICY FOR THE LITTLE SASKATCHEWAN RIVER WATERSHED

BMP	Target Adoption Rate	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	TOTAL
	16%	254,677	64,668	55,504	54,902	54,391	29,824	29,164	28,526	28,022					599,680
	32%		254,677	64,668	55,504	54,902	54,391	29,824	29,164	28,526	28,022				599,680
Grassed riparian buffer zones	48%			254,677	64,668	55,504	54,902	54,391	29,824	29,164	28,526	28,022			599,680
	64%				254,677	64,668	55,504	54,902	54,391	29,824	29,164	28,526	28,022		599,680
	80%					254,677	64,668	55,504	54,902	54,391	29,824	29,164	28,526	28,022	599,680
PAYMENTS ($) (actualized)	**(A)**	**254,677**	**310,044**	**353,332**	**393,284**	**430,155**	**223,666**	**187,417**	**160,023**	**134,142**	**88,549**	**63,778**	**40,852**	**19,654**	**2,659,573**
	0.60%	68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005					544,036
	1.20%		68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005				612,041
Converting marginal land to wetland	1.80%			68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005			612,041
	2.40%				68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005		612,041
	3.00%					68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005	68,005	612,041
PAYMENTS ($) (actualized)	**(B)**	**68,005**	**132,048**	**192,302**	**248,935**	**302,106**	**293,307**	**284,764**	**276,470**	**268,417**	**208,479**	**151,805**	**98,256**	**47,697**	**2,572,590**
	1.60%	39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176					313,404
	3.20%		39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176				352,580
Cover crops for cereals	4.80%			39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176			352,580
	6.40%				39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176		352,580
	8.00%					39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176	39,176	352,580
PAYMENTS ($) (actualized)	**(C)**	**39,176**	**76,069**	**110,780**	**143,405**	**174,035**	**168,966**	**164,045**	**159,267**	**154,628**	**120,099**	**87,451**	**56,603**	**27,477**	**1,481,998**
PAYMENTS FOR PHOSPHORUS ($) (actualized) (include payments for habitat)	**(A)+(B)+(C)**	**361,857**	**518,161**	**656,414**	**785,624**	**906,296**	**685,938**	**636,225**	**595,759**	**557,187**	**417,127**	**303,034**	**195,710**	**94,828**	**6,714,162**
PAYMENTS FOR HABITAT ($) (actualized) [53]	**10%*(B)**	**6,800**	**13,204**	**19,230**	**24,893**	**30,210**	**29,330**	**28,476**	**27,647**	**26,841**	**20,847**	**15,180**	**9,825**	**4,769**	**257,259**
PAYMENTS FOR PHOSPHORUS & HABITAT ($) (actualized)	**(A)+(B)+(C)**	**361,857**	**518,161**	**656,414**	**785,624**	**906,296**	**685,938**	**636,225**	**595,759**	**557,187**	**417,127**	**303,034**	**195,710**	**94,828**	**6,714,162**

[53] The payments for habitat are considered to be equal to 10% of the payments for wetlands as the 550 ha of habitat represents 10% of the total 5,505 ha of wetlands restored via this practice.

This simulation for the Little Saskatchewan River reveals that a P loading could be reduced by 11.9 tonnes through grassed riparian buffers. The total cost of these BMP incentive payments would be $2.659 million.

Our target implementation rate for cover crops is 8% of agricultural land in the watershed, for a total area of 14,091 ha under cover crops. The annual P loading reduction is estimated to be 5.6 tonnes per year, and the payments would total $1.5 million.

Our analysis assumes that 3% of land presently under agricultural production is converted to wetlands, for a total increase in habitat of 5,505 ha. This has a P loading reduction benefit of 5 t per year. The total project payments for this BMP are $2.6 million, but only 10% of these payments are considered for habitat creation because the objective is fixed at 550 ha.

Total incentive payments through an annual payments policy are estimated at $6.71 million for the Little Saskatchewan River case study (see Table 32).

3.2.1.3. Mixed One-Time/Annual Payments

This policy covers practices that can be compensated by one-time or annual payments. The policy is designed to ensure that practices producing a higher level of EG&S at the lowest cost will be implemented first. We will therefore calculate the cost-effectiveness of each of the BMPs analyzed in terms of both cost per environmental benefit obtained and potential contribution to achieving the target environmental objective. We will then rank the practices on the basis of their effectiveness, and the most cost-effective will be chosen first. The others then follow in descending order of environmental effectiveness. The last practice selected will be the one through which the target environmental objective is reached for every concerned watershed.

In the case of practices designed to improve water quality, we estimate their ability to reduce phosphorous discharge in watercourses at the least cost, as well as their overall phosphorous reduction potential when applied in our watershed. With respect to BMPs designed to preserve habitat (wetland and woodland in agricultural areas), the environmental benefit indicator is the cost of preserving one hectare of woodland and wetland through the various BMPs.

Nicolet

The practices compensated by one-time payments on the Nicolet sub-watershed are grassy riparian buffer strips, conservation tillage, direct seeding and cover crops. The practices covered by annual payments are wooded riparian buffer strips, intercropping, preservation of woodland and wetland in agricultural areas and crop reduction on agricultural floodplains. The question of choosing one-time or annual payments to compensate the various practices takes into account the total cost of applying a given practice to the entire watershed.

Grassed Riparian Buffer Strips

We assume that in the Nicolet sub-watershed, almost all agricultural producers (85%) are in compliance with the requirement to leave a three-metre-wide strip along watercourses. In addition, the expected adoption rate for the 10-metre grassy riparian buffer strip is 60%.

The actualized cost of establishing a grassy riparian buffer strip 10 metres wide within the watershed is $0.343 million. Given that a hectare of 10-metre riparian buffer strip can exclude 0.11 kg of TP per hectare of cultivated land more than a 3-metre riparian buffer strip, the potential total quantity of phosphorus excluded in the overall watershed is 1.88 tonnes. This is equivalent to a cost of $183/kg of phosphorus excluded.

Conservation Tillage (No-Till and Reduced Tillage Using a Chisel Plough)

With an assumed adoption rate of 35% for every BMPs (no-till and reduced till using a chisel plough), their estimated potential for reducing phosphorous in the watershed's watercourses is 2.47 tonnes. Given that these practices entail major capital investment, especially for the purchase of seed drills, we anticipate that such investment in purchasing specialized equipment will be covered up to a pre-set limit of 30% of the purchase price[54] to a maximum of $15,000. For each of these practices, the cost of excluding a kilogram of phosphorous from watercourses is estimated at $402.

Cover Crops

The cost of applying this practice in the watershed is $18,707 with an estimated adoption rate of 40%. With cover crops, we can expect to exclude 0.489 tonnes of phosphorus from watercourses at an estimated cost of $38/kg.

[54] Measure based on the Canada-Manitoba Farm Stewardship Program.

Wooded Riparian Buffer Strips

The adoption rate of this practice in the watershed is approximately 80%. The actualized cost of establishing wooded riparian buffer strips 10 metres wide within the watershed is $2.247 million. The amount of total phosphorus excluded is estimated at 2.5 tonnes. The cost-effectiveness of this practice in terms of environmental benefit obtained per dollar spent is $897 per kilogram of phosphorous excluded from watercourses.

Intercropping

The actualized cost of applying this practice in the watershed is $2.346 million with an estimated adoption rate of 20%. With intercrops, a phosphorous reduction of 0.938 tonnes is expected at an estimated cost of $2,501/kg.

Preserving Woodland in Agricultural Areas

Given current cutting restrictions in Quebec, it is assumed that this practice has a potential adoption rate of only 3%. The estimated total actualized cost of preserving 825 ha of woodland in our watershed is $325,206 at an average cost of $395/ha.

Preserving Wetland in Agricultural Areas

In Quebec, section 22 of the province's *Environment Quality Act* regulates the drainage of wetlands. This section defines the conditions that need to be met (which vary depending on individual circumstances) for growing crops on wetlands. The purpose of this practice is to help protect wetlands in situations where, under certain conditions, crops could be grown on them. An adoption rate of 80% is assumed for this practice at an estimated average cost of $605 to preserve one hectare of wetland.

Restoration of Agricultural Floodplains

The estimated cost per hectare of agricultural floodplain withdrawn from production is $1,091.

We will now look at the total payments per target environmental objective because, as mentioned above, the most effective practices in terms of cost per environmental benefit obtained will be implemented first.

Table 33 shows, in descending order of environmental benefit, the BMPs designed to lower phosphorous levels in watercourses. It is important to note that the practices which have proved to be the most effective in terms of cost per target environmental benefit are those compensated by a one-time payment (cover crops, grassed riparian buffer strips, reduced tillage and no-till).

TABLE 33 : ENVIRONMENTAL COST-EFFECTIVENESS OF PRACTICES TO REDUCE PHOSPHOROUS LOADS IN WATERCOURSES (NICOLET EAST)

EG&S	BMP	Environmental cost-effectiveness	Phosphorous reduction (tonnes of TP)	Final concentration after implementing the BMP (mg TP/l)	Cumulative payment ($)
Phosphorous reduction	Cover crops	$38/kg TP	0.489	0.040	18,707
	Grassy riparian buffer strips	$183/kg TP	1. 88	0.038	362,142 (+343,435)
	Reduced tillage and no-till	$402/kg TP	2.47	0.036	1,356,242 (+994,100)
	Objective achieved				
	Wooded riparian buffer strips	$897/kg TP	2.506		
	Intercropping	$2,501/kg TP	0.938		
Total payment to improve water quality					**1, 356,242**

With regard to water quality improvement, it should be noted that the payment total under a combined one-time and annual payment policy, in which the most cost-effective practices are implemented first, ends up being the same as the total under a one-time payment policy, namely, $1,356,242.

With respect to habitat preservation, given that we have the same objective in terms of habitat creation (number of ha) and that annual payments are less than one-time payments, total payments for the mixed one-time/annual payments equal those for annual payments, i.e. $0.545 million.

Table 34 shows, in descending order of environmental cost-effectiveness, the BMPs designed to preserve habitat in our watershed.

TABLE 34 : ENVIRONMENTAL COST-EFFECTIVENESS OF PRACTICES DESIGNED TO PRESERVE HABITAT (NICOLET EAST)

EG&S	BMP	Environmental cost-effectiveness	Habitat preservation (ha)	Cumulative cost ($)
Habitat preservation	Preserving woodland in agricultural areas	$394/ha	825	325,206
	Preserving wetland in agricultural areas	$605/ha	310	512,697 (+187,491)
	Withdrawal of agricultural floodplains from production	$2,521/ha	30	545,438 (+32,741)
Total payments to preserve habitats				**545,438**

Total payments associated with a combined policy of one-time and annual payments in the Nicolet sub-watershed come to $1.90 million, which is lower than the total estimated amount for either one-time payment ($1.96 million) or annual payment policies ($5.33 million).

Little Saskatchewan River

In Manitoba, the method used to select BMPs for the mixed payment policy involved selecting the BMPs with the lowest cost of reducing phosphorous on a dollars-per-kg basis. According to Table 35, it would appear that the BMPs with the greatest cost effectiveness are both found in the one-time payment portfolio. The most cost effective BMPs are grassed riparian buffer zones with a cost effectiveness of $19.17 per kg of P reduced and manure storage with a cost effectiveness of $41.46 per ha of P reduced.

TABLE 35 : COST EFFECTIVENESS OF BMPS IN THE ONE-TIME AND ANNUAL PAYMENT PORTFOLIOS

	Payments	% Implemented	p reduced (tonnes)	Cost of P reduction ($/kg P)	Habitat Created (ha)	Cost ($/ha)
ANNUAL PAYMENTS						
Wooded Riparian Buffer zones	2,659,573	80.00%	11.9	224.04	443	6,004
Wetlands	2,572,590	3.00%	5.0	519.28	5,505	467
Cover Crops	1,481,998	8.00%	5.6	262.92		
ONE TIME PAYMENTS						
Grassed Riparian Buffer Zones	227,594	80.00%	11.9	19.17	443	514
Wetlands	2,062,358	3.00%	5.0	416.29	5,505	375
Manure Storage	265,344	5.00%	6.4	41.46		

When the lowest-cost BMPs are applied to the watershed, we see that the objective of a 75% reduction in P loading can be achieved with 100% implementation of grassed riparian buffer zones and a 6% implementation of 200 day manure storage (see Table 36).

TABLE 36 : PAYMENTS TO PRODUCERS AS PART OF A MIXED ONE-TIME/ANNUAL PAYMENT PROGRAM IN THE LITTLE SASKATCHEWAN RIVER

YEAR	1	2	3	4	5	TOTAL
Grassed riparian buffer zones						
Target adoption rate	*20.00%*	*40.00%*	*60.00%*	*80.00%*	*100.00%*	
Payments	60,311	60,311	60,311	60,311	60,311	
Actualized payments	60,311	58,554	56,849	55,193	53,585	284,492
Manure Storage						
Target adoption rate	*1.21%*	*2.41%*	*3.62%*	*4.82%*	*6.03%*	
Payments	67,807	67,807	67,807	67,807	67,807	
Actualized payments	67,807	65,832	63,914	62,053	60,245	319,851
Total actualized payments	**128,118**	**124,386**	**120,763**	**117,246**	**113,831**	**604,343**

The total payments to producers from this policy will be $0.6 million. While this is officially a mixed payment portfolio, in fact all the payments will be delivered on a one-time basis. The phosphorous objective can be achieved using the two most cost effective BMPs, both of which are formulated on a one-time basis.

3.2.1.4. Auctions and Tradable Permits

In an auction system, producers make a proposal specifying the payment that they would like to receive in exchange for implementing BMPs (*willingness to accept*). Only the best proposals having the best environmental ratio (in terms of environmental benefit obtained per cost) are chosen until the target environmental objectives are achieved.

In the case of tradable permit systems, the process is based on the fact that pollution reduction costs to achieve a given target are not uniform among system participants. Thus a pollution source with high pollution reduction costs would rather purchase emission reductions or rights from another lower-cost source than reduce its own emissions.

We believe that both of these market-based mechanisms (auctions and tradable permits) are effective systems and consequently, practices producing a higher level of EG&S at the lowest cost will be implemented first. The efficacy of each BMP analyzed is calculated in terms of both its cost per environmental benefit obtained as well as its potential contribution to achieving the target environmental objective. Practices are ranked on the basis of their environmental efficacy so that the most effective will be chosen first.

Given the differences among producers in the cost of the same practice, the objective is to determine how many practice-related measures can be implemented for a given payment level. To determine this, cost distribution functions based on the target EG&S will be established for each practice. We assume that this will be a normal distribution, the average of which will correspond to the average total actualized cost of excluding a kilogram of phosphorus, from watercourses or preserving a hectare of woodland or wetland in agricultural areas. The standard deviation, which defines the producer cost variation for the same practice, will vary as a function of the least possible cost for each practice. The level of payment per least-cost EG&S is then used to try to "capture" the producers capable of implementing each practice at a cost per EG&S equal to or lower than the average cost of the most effective practice until the target EG&S is achieved. See appendix 20 for figures explaining the calculations in graphic form.

Nicolet

For the Centre-du-Québec region, Table 37 shows the practices ranked on the basis of their environmental efficacy in terms of average cost required either to exclude a kilogram of phosphorus from watercourses or to preserve a hectare of habitat within the watershed. The fourth column shows the percentage of producers with a cost of excluding a kilogram of phosphorus or establishing a hectare of habitat equals to or lower than the average cost of the most effective practice.

TABLE 37 : PERCENTAGE OF PRODUCERS WITH A PHOSPHORUS EXCLUSION/HABITAT PRESERVATION COST EQUAL TO OR LOWER THAN THE MOST EFFECTIVE PRACTICE

PHOSPHORUS

Practice	Average total actualized cost ($/kg TP)	Standard deviation	Percentage of producers with a cost equal to or lower than the average of the most effective BMP
Cover crops	209	41.8	50%
Grassy riparian buffer zones	275	55	12%
Reduced tillage and no-till	539	188.65	8%
Wooded riparian buffer zones	1,127	338.1	0.33%
Intercrops	3,101	620.2	0.00%

HABITAT

Practice	Average total actualized cost ($/ha)	Standard deviation	Percentage of producers with a cost equal to or lower than the average of the most effective BMP
Woodlands	481	72.15	50%
Wetlands	722	216.6	13%
Agricultural floodplains	1,316	394.8	2%

It is clear that planting cover crops is the most cost-effective practice for achieving the phosphorus target, followed by grassy riparian buffer zones, conservation tillage, direct seeding, wooded riparian buffer zones, and intercrops (in that order). In terms of conserving habitat, maintaining woodlands comes first, followed by maintaining wetlands in agricultural areas and reducing cropping in agricultural floodplains (in that order).

However, if the adoption rate of the various practices is applied when the cost per kilogram of phosphorus is equal to or lower than the cost of the most effective practice (cover crops), the target is not achieved. The exercise is then repeated with the second most effective practice as the benchmark. The results obtained for the various practices are shown in Table 38.

TABLE 38 : PERCENTAGE OF PRODUCERS WITH A PHOSPHORUS EXCLUSION COST EQUAL TO OR LOWER THAN THAT OF THE SECOND MOST EFFECTIVE PRACTICE

Practice	Average total actualized cost ($/kg TP)	Standard deviation	Percentage of producers with a cost equal to or lower than the average of the most effective BMP
Cover crops	209	41.8	94%
Reduced tillage and no-till	539	188.65	8%
Grassy riparian buffer zones	275	55	50%
Wooded riparian buffer zones	1,127	338.1	0.59%
Intercrops	3,101	620.2	0.00%

With these new adoption rates, the goal of excluding phosphorus from watercourses is only achieved with the three most effective practices. In fact, an adoption rate of 6% for the “reduced tillage” and “no-till” practices would be sufficient to achieve the target.

The “maintaining habitat” objective is also achieved with a payment corresponding to the average cost of the most effective practice (maintaining woodland in agricultural areas). Furthermore, an adoption rate of only 4.2% for this practice would be sufficient to achieve the target.

PHOSPHORUS

Practice	Payment level ($/kg TP)	Phosphorus reduction potential (kg TP/ha)	Potential area (ha)	Adoption rate	Total payments ($)
Grassy riparian buffer zones	275	0.11	28,478	50%	430,736
Cover crops	275	0.4	5,561	94%	575,007
Reduced tillage and no-till	275	0.35	20,051	12%	231,589
Total payments:					1,237,333
Total actualized payments:					732,375

HABITAT

Practice	Payment level $/ha	Total area of wooded farmland (ha)	Adoption rate	Total payments ($)
Woodlands	481	27,500	4.20%	555,555
Total payments:				555,555
Total actualized payments:				328,832

For the Centre-du-Québec region, Table 39 shows total actualized payments if a policy based on market instruments (auctions and tradable permits) is set up. In the case of auctions, the total payment corresponds to the total cost per practice for the entire watershed. In the case of the tradable permit system, a part of the payments will be assumed by point pollution sources – a portion that we estimate at 25%.[55] The government's contribution will thus cover 75% of the total payments for the watershed.

[55] Hypothesis based on the experience of operating a tradable permit system in the South Nation River watershed in Ontario.

TABLE 39 : TOTAL PAYMENTS: AUCTIONS AND TRADABLE PERMITS IN NICOLET WATERSHED

PHOSPHORUS

Practice	Payment level ($/kg TP)	Phosphorus reduction potential (kg TP/ha)	Potential area (ha)	Adoption rate	Total payments ($)
Grassy riparian buffer zones	275	0.11	28,478	50%	430,736
Cover crops	275	0.4	5,561	94%	575,007
Reduced tillage and no-till	275	0.35	20,051	12%	231,589
Total payments:					1,237,333
Total actualized payments:					732,375

HABITAT

Practice	Payment level $/ha	Total area of wooded farmland (ha)	Adoption rate	Total payments ($)
Woodlands	481	27,500	4.20%	555,555
Total payments:				555,555
Total actualized payments:				328,832

Total payments for the Nicolet sub-watershed to achieve the phosphorus reduction target come to $0.73 million. The amount needed to achieve the habitat objective is $0.33 million.

In the case of an auction system, the payments for the Nicolet watershed are estimated at $1.06 million, which is the sum of the amounts needed to achieve the two objectives. In the case of the tradable permit system, we consider only total payments for phosphorus reduction. It is also necessary to take into account the fact that part of the payments for phosphorus reduction comes from point pollution sources – a portion that we estimate at 25% of total payments. The government should then pay the remaining 75%, i.e., $549,281.

Little Saskatchewan River

Following the same methodology to determine the payment methods for market-based instruments that was used in the Nicolet case study, we are able to demonstrate the applicability of these instruments, namely auctions and nutrient trading, to the Little Saskatchewan River in Manitoba.

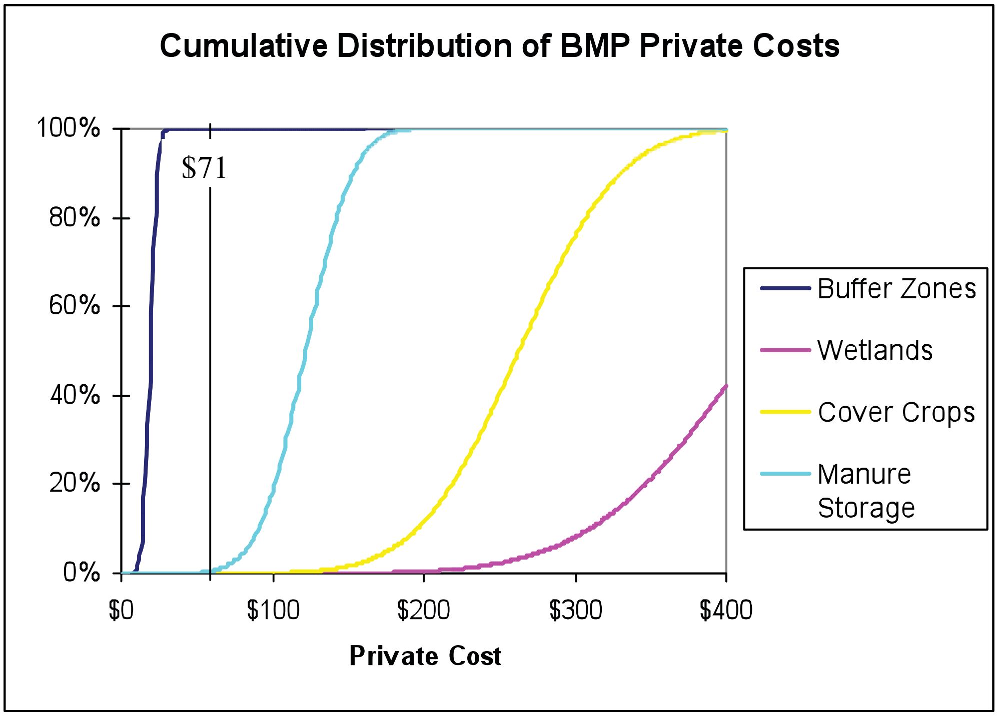
This analysis postulates that the costs of implementing a BMP vary between producers. Accepting a payment for implementing a BMP is more likely to be done by producers who can do so most cheaply, regardless of the practice. This methods assumes that the cost of implementing a BMP is an estimate of the mean private cost and that the standard deviation can be estimated. Assuming that the standard deviation of the private costs of BMP adoption is one-quarter of the average private cost, we can interpolate to determine the minimum private cost level to which a 75% reduction in P loading gives the results in Table 40. Through the interpolations, it was revealed that the desired level of P reduction could be achieved by implementing all BMPs with a private cost of $71 or less.

TABLE 40 : COST OF ACHIEVING A 75% REDUCTION IN P LOADING ON THE LITTLE SASKATCHEWAN RIVER WATERSHED USING MARKET-BASED INSTRUMENTS

BMP	Average cost ($/kg of P reduced)	Standard Deviation ($/kg P)	Implementation Rate	P reduced (tonnes)	Cost ($)
Riparian Buffer Zones (grassed)	19.17	3.83	100.0%	14.84	284,492
Wetlands	416.29	83.26	0	0	
Cover Crops	262.92	52.58	0	0	
Manure Storage	41.46	8.29	5.9%	7.55	313,098
Total				22.39	597,590
Total actualized payments					**353,729**

Based on the distributions plotted in Figure 4, this represents a 100% uptake of the grassed riparian buffer zone BMP and a 5.9% implementation of manure storage. The total cost of this approach is $0.35 million in actualized dollars.

FIGURE 4 : GRAPHICAL REPRESENTATION OF LITTLE SASKATCHEWAN RIVER PRIVATE BMP COSTS



According to this analysis, the total actualized payments to producers from implementing market-based instruments will total $0.35 million (this figure represents the total amount of payments, as opposed to the total program cost of $0.62 million). In an auction or tender program, all of these payments will be borne by the government. In a nutrient trading scheme, a portion of these payments will come from the credit purchasers.

In the Nicolet watershed, it is assumed that 25% of the payments would come through trading. For the Little Saskatchewan River watershed, this percentage would likely be somewhat lower due to the relative lack of point sources of P compared with the eastern case. Manitoba is a sparsely populated, highly urbanized province with two-thirds of the population living in Winnipeg. Generally, point sources of effluent are already licensed. Licences under the Environment Act are typically in effect for 20 years, so any tightening of effluent limits in order to create a market for credits would likely take 20 years to be fully implemented. Also, the relative scarcity of large potential credit purchasers could be a challenge in developing a nutrient-trading scheme. For Manitoba it is assumed that only 10% of the payments in a nutrient-trading program would come from the purchase of credits. The total payments to producers from implementing a nutrient-trading program will total $0.662 million.

Table 41 shows total payments of different policies in the Nicolet sub-watershed and the Little Saskatchewan River study.

TABLE 41 : TOTAL PAYMENTS OF DIFFERENT POLICIES IN THE NICOLET AND THE LITTLE SASKATCHEWAN RIVER WATERSHEDS

	Nicolet (Million $)	Little Saskatchewan River (Million $)
One-time payments	1.75	2.55
Annual payments	4.2	6.71
Mixed one-time/annual payments	1.68	0.60
Auctions	1.06	0.35
Tradable permits (for P only in Nicolet)	0.55	0.32

It is clear that the payment levels for market-based policies (auctions and tradable permits) are lower than payment levels for direct payments policies.

3.2.2. Public Transaction Costs

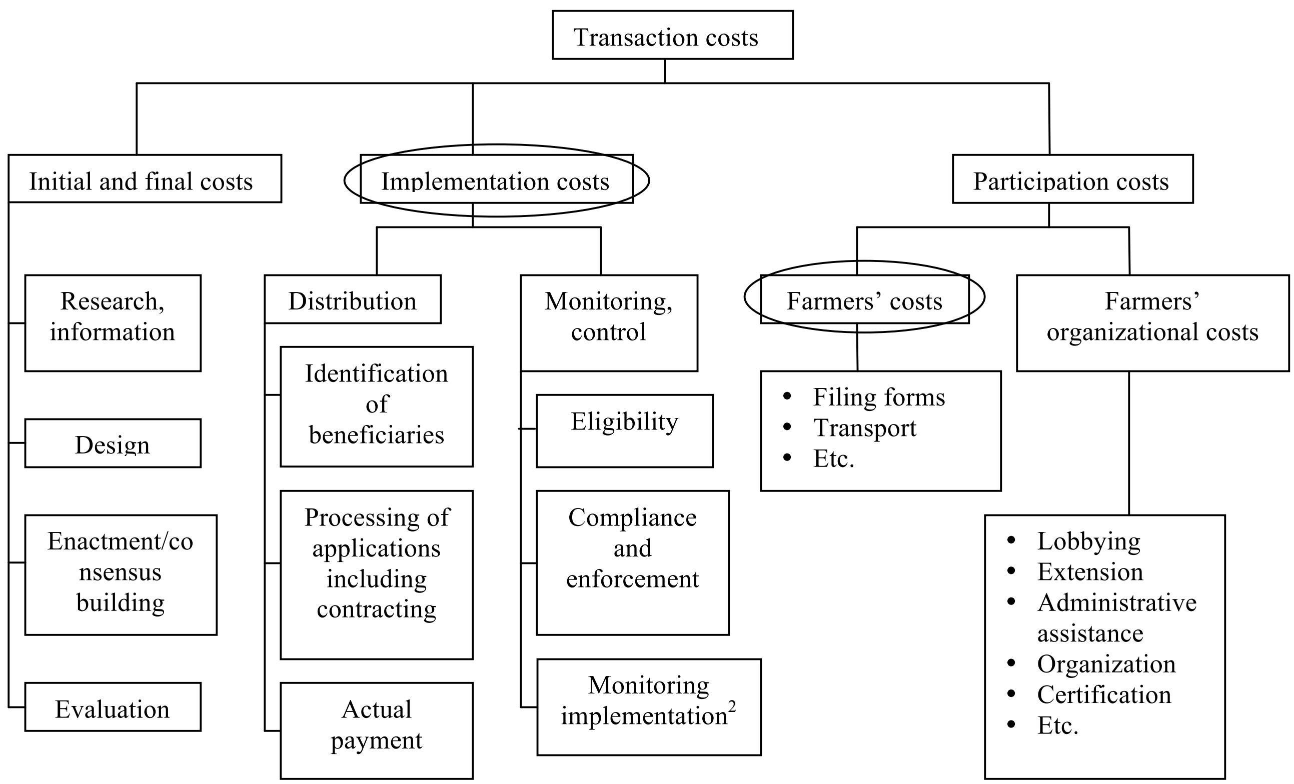
About Transaction Costs

The concept of transaction costs originally referred to factors hampering transactions in the marketplace, such as information search costs, market shortcomings and efforts to head off opportunism by other players, etc. This concept was used for the first time in 1937 by economist Ronald H. Coase. Today, the concept has been broadened to include all the costs associated with allocation-related decisions, regardless of whether such decisions are made in the marketplace or by public authorities (OECD, 2001b). Furubotn and Richter (Furubotn and Richter, 1998) classified transaction costs into three major categories (OECD, 2007a):

1) *Policy-related transaction costs*: these are the costs of creating, maintaining and amending the institutional framework of a given policy, and the costs of policy implementation;
2) *Management transaction costs*: these are the costs of creating, maintaining, modifying and operating organizations;
3) *Market transaction costs*: these are the costs related to research, information, negotiating and decision-making, as well as the costs of verifying compliance in relation to marketplace transactions.

The first and third categories mentioned above are covered in this section on transaction costs. Figure 5, which is taken from OECD (OECD, 2007), summarizes all the transaction costs associated with implementing agricultural policies. This figure classifies the various transaction cost subcategories into (i) initial and final costs, (ii) implementation costs, and (iii) participation costs. This study deals with the latter two subcategories – and, as shown in Figure 5, it is possible for farmers to partly cover participation costs. We will thus make a distinction between public and private costs in examining policy-related costs. We will also make the same distinction with respect to marketplace transaction costs, which are basically associated with market-based policy instruments.

FIGURE 5 : SUBCATEGORIES OF TRANSACTION COSTS RELATING TO BUDGETARY PAYMENT POLICIES



Source: OECD (2007).

In general, the categories of transaction costs shown in *Figure 5.* apply to all types of policies. However, differences can exist depending on the policies implemented. This is the case, for example, in distribution and monitoring/control costs. While initial start-up and final evaluation costs are generally fixed, these costs, as we have noted, are not covered in this study with the exception of market-instrument-based policies.[56] Implementation costs, however, usually vary between policies.[57] By definition, variable costs will increase in proportion to program size. OECD (OECD, 2007) emphasizes the importance of making the distinction between fixed costs and variable costs insofar as this affects a given program's ability to channel major transfers. Table 42 shows the types of policy payment costs that can be identified as either fixed or variable.

TABLE 42 : VARIOUS CATEGORIES OF PUBLIC TRANSACTION COSTS

	Cost types	
Cost items	Fixed	Variable
Policy design	√	
Agreement negotiations		
Promoting the program to farmers	√	√
Negotiating requirements		√
Provisioning and distributing payments		
Identifying beneficiaries		√
Processing applications (eligibility)		√
Disbursing payments		√
Monitoring and control		
Eligibility		√
Compliance with requirements		√
Evaluation	√	
Applying requirements and verifying compliance		√

Sources: Adapted from OECD (2007) Tables 1.1 and 1.2.

In the case of market-based policies, costs basically vary, affecting administrative operations in the organizations where permit trading transactions and/or auctions take place and where contract compliance is monitored. As Smith pointed out (Smith, 2002): "*... These [costs] include administrative costs incurred by regulatory agencies for emissions measurement, monitoring and regulating permit transactions…"*

[56] The fact that these costs do not vary from policy to policy means that it is not relevant to study them here. Furthermore, they constitute a relatively small portion of the total costs of the policies studied.
[57] Implementation costs are generally variable for both public agencies and farmers, although farmers can also incur fixed costs: for example, when the program requires the collection of prior information.

In the next section, we will present the approach used to estimate the public cost of implementing the policy selected. We will then estimate the level of public cost incurred for each policy selected.

Estimating Public Transaction Costs

Several approaches can be used to measure the public transaction costs of policy implementation (OECD, 2007):

Direct estimate: The aim of this approach is to estimate transaction costs on the basis of interviews with the various stakeholders involved in policy implementation. Because of the limited time available, this approach was not included in this study.

Bottom-up approach: This approach involves studying the information contained in detailed studies of a small number of "typical" cases and then proceeding by extrapolation. This method is appropriate when the number of people involved, such as farmers and local players, is high because it reduces estimating costs. To our knowledge, however, this type of approach was not used in Quebec or Manitoba and would therefore be difficult to use in this study.

Top-down approach: This approach involves establishing a list of all the organizations involved in implementing, monitoring and overseeing policies and then collecting information on their overall administrative costs, as specified in their respective budgets. In some cases, the same organization can be responsible for implementing several policies. Such is the case of the FAQ (Financière agricole du Québec)[58] and the CDAQ (Conseil pour le développement de l'agriculture du Québec)[59] in Quebec. Wherever possible, this information will then need to be allocated according to the various policies concerned.

We have applied the top-down approach in this study, basing our work on the transaction costs of past or present policies. We have thus based our study on work produced in the United States and/or certain European Union countries. We have taken into account the various factors that influence the different costs, such as policy characteristics, the implementation network, expected level of participation, etc.

[58] In addition to the various insurance programs (crop, income stabilization and loan), the FAQ manages or has managed, for example, specific programs set up following health crises such as Bovine Spongiform Encephalopathy (BSE) or Post-weaning Multi-systemic Wasting Syndrome (PMWS) in hogs. See http://www.fadq.qc.ca/index.php?id=6 (Page consulted on December 7, 2007).

[59] The CDAQ currently delivers seven different programs, including the Greencover Canada Program. This program offers a one-time payment to producers for implementing certain BMPs. See http://www.cdaq.qc.ca/ (Page consulted on December 7, 2007).

One of this study's difficulties lies in the availability of accurate data on the various transaction cost components. This difficulty recurs in the various studies on program and policy transactions costs, especially when their implementation does not constitute a particular organization's sole activity (see OECD, 2007; OECD, 2002).

The information gathered and analyzed for this study covers both implementing organizations and contracted agencies (banks, insurance companies, etc.). Wherever possible, the following information is classified and analyzed for each implementing agency: (i) the different types of government measures and the various implementation stages; (ii) the different organizations involved in routing and overseeing policy at all levels of government; (iii) budgetary information on each organization's administrative costs; (iv) each organization's structure (organization chart), i.e., its various sections or administrative units; and (v) the cost of each task. The contracted agencies that are relevant for this study are basically banks and insurance companies. They are generally involved in implementing existing policies. This component basically concerns the interest and capital costs incurred in the various programs.[60]

Unless otherwise indicated, the public costs of policy implementation are expressed as a percentage of total disbursements made.

3.2.2.1. Transaction Costs Incurred by Federal and Provincial Programs

The BSE Recovery Program is one example for which budgetary headings on the transaction costs incurred by federal and Quebec government departments were clearly identified. These public transaction costs were 1.7% for Agriculture and Agri-Food Canada (AAFC) and 1.3% for MAPAQ.[61] However, it appears from the documents consulted that the general transaction costs identified by MAPAQ are approximately 18.3% of all the transfer credits for its main agricultural sector interventions.[62, 63] These administrative expenses cover the costs directly incurred by MAPAQ as well as those incurred by the implementing agencies for some of its policies (including FAQ).

[60] It is also important to bear in mind that certain revenue factors also exist, e.g., those associated with capital investments.
[61] The total annual cost of the program has been just over $95 million.
[62] These interventions are combined in Program 1, "Bio-food enterprise development, training, and food quality" and Program 2, "Government organizations," especially the credits allocated to FAQ. Available at http://www.tresor.gouv.qc.ca/fr/documentation/secteur/budget.asp.
[63] These data are consistent with those in the AAFC report entitled *Farm Income, Financial Conditions and Government Assistance. Data Book for September 2007.* According to the budget forecasts or estimates in this report, operating expenses represented approximately 20% of MAPAQ's total expenditures for 2006/2007 and 2007/2008. Available at: **http://www.agr.gc.ca/pol/index_f.php?s1=pub&s2=cond-fin-sit&page=intro**.

Funding for the Farm Stewardship Association of Manitoba (FSAM) comes from the Canadian and Manitoban governments as part of the current Environmental Policy Framework. According to published documents, the total cost of the Environmental Farm Planning Program for Manitoba is $43.07 million (AAFC, 2005; MAFRI, 2005). As of October 2007, $38.99 million has been committed to producers (MAFRI, 2007). If $38.99 million of $43.07 million has presently been allocated to producers, this suggests that $4.08M has been spent on administration, meaning that administration costs are 10.5% of payments. However, it is important to note that massive in-kind support was provided by MAFRI and the Prairie Farm Rehabilitation Agency to the Environmental Farm Planning process. The implication is that the total cost of the Environmental Farm Planning program likely exceeds the stated $43.07 million cost.

An analysis of the ALUS program has been conducted by Dr. Charles Grant, senior instructor in University of Manitoba's Agribusiness and Agriculture Economics Department (George Morris Centre, 2008). The analysis determined that development expenditures were $401,000, while payments to producers amounted to $601,000 divided approximately equally between two years (George Morris Centre, 2008). Development costs are therefore estimated to be 67% of producer payments (George Morris Centre, 2008). Ongoing operational and administrative costs were estimated at 22% of producer payments in the first year and 15% of producer payments in the second year (George Morris Centre, 2008).

The estimated costs for the Environmental Farm Planning and ALUS programs in Manitoba are provided for demonstration onlybecause the limited and different sets of information on which they are based do not allow for direct comparison. Additionally, there are key structural differences that make this comparison difficult. ALUS is a small pilot program operating in a small area and is not representative of a watershed EG&S program. Also, ALUS was started from scratch, whereas a government project would be able to draw on existing federal and provincial resources. Being a small pilot project, ALUS is also unable to take advantage of economies of scale that would reduce establishment and administration costs. The Farm Stewardship Association of Manitoba operates over the entire province and is able to draw on existing resources and infrastructure.

Transaction Costs of Agencies Implementing Direct Payment Policies (One-Time and Annual Payments) at the Provincial Level

As already mentioned, the CDAQ manages federal BMP programs in Quebec, including the Greencover Canada Program, which is a one-time payment program. The CDAQ has also implemented a number of other programs and still does.

Table 43 shows the administrative costs of the various payments made by the CDAQ. This table shows that for the period from 1996 to 2007, program management expenses accounted for 12% of total disbursements made to producers.

TABLE 43 : CDAQ'S ADMINISTRATIVE EXPENSES IN IMPLEMENTING POLICIES

	2006-2007	1996-2007
Total amount disbursed	$13,040,522	$78,582,546
Management expenses	$1,274,959	$9,435,883
Total amount awarded	$17,279,493	$88,988,107
Number of projects	337	1,271
Management expenses/total amount disbursed	9.8%	12.0%

In Quebec, the FAQ also plays a vital role in implementing and/or managing provincial and federal programs. Over its last five years of operation, this organization's average annual administrative expenses amounted to approximately 11.9% of its disbursements, including 1.9% for interest costs, write-offs and investment losses.[64] The FAQ's general administrative expenses are thus close to the CDAQ's.

However, the FAQ manages a very broad range of programs. Table 44 provides a brief description of some of these programs as well as the average percentage of administrative costs incurred relative to payments to producers. In each case, the payments to producers require the FAQ to complete and process forms. These expenses basically involve: *(i)* promoting the programs to producers; *(ii)* provisioning and distributing payments; and *(iii)* monitoring and controlling programs.

[64] See FAQ's various reports at http://www.fadq.qc.ca/index.php?id=117&no_cache=1.

TABLE 44 : FAQ'S ADMINISTRATIVE EXPENSES IN IMPLEMENTING CERTAIN AGRICULTURAL POLICIES

Program	Description	Transaction costs (%)[(a)]	Comments
Farm Income Stabilization Insurance (FISI) Program	Provides protection against market price fluctuations. Compensation paid to participants when net annual income is lower than stabilized income.	4.7%	This program is highly standardized, which tends to reduce transaction costs.
Crop Insurance Program	Insures farming enterprises against risks not related to human activity.	27.2%	This program inherently involves higher oversight costs.
BSE Recovery Program	Offers financial support to enterprises in crisis (Component 1) and assists in the search for funding through loan guarantees (Component 2).	1.5%	These expenses represent part of the program costs, especially its financial component.
Special assistance program for hog farms affected by post-weaning wasting syndrome (Component 1)	Offers special assistance to hog farms affected by post-weaning wasting syndrome.	1.7%	These expenses represent part of the program costs, especially its financial component.

(a) This percentage represents the average of transaction costs compared with the compensation paid to producers.

Table 44 shows that the transaction cost percentage varies very widely, depending on the particular nature of the FAQ-managed program or program component. According to OECD (OECD, 2007), the average insurance program transaction cost percentage in Canada during the 1990s was 15%, a level lower than that in either the United States or Europe. However, in his first report to Quebec's National Assembly, Quebec's Sustainable Development Commissioner stated that only 9% of producers with FISI in 2005 were monitored for compliance with environmental requirements. In 2006, only hog producers were monitored (Auditor General of Quebec, 2008 page 71). As a result, the transaction costs relating to FISI implementation are underestimated, since compliance with the environmental requirements concerned was not verified. Another reason for these differences could be economies of scale.[65]

[65] Wages represent slightly more than 70% of the FAQ's administrative expenses. As a result, even when producer payments are lower in one program than in the other, we can assume that file processing times do not differ greatly between the two programs.

The FAQ's transaction costs are lower for the two special-case programs shown in Table 44: the BSE Recovery Program and the special PMWS assistance program, for which transaction costs average 1.6% of total payments. However, both these programs are included within the basic insurance programs (Quebec and/or federal) to which producers must subscribe. Producers therefore already have files with FAQ, which can help reduce administrative costs.

Administrative Costs of Auction and Tradable Permit Systems

Two institutions were used as a framework for studying the administrative costs of a trading system: Quebec's centralized milk quota trading system (SCVQ) and the auction mechanism used in the Quebec hog industry. Although we do not have any information on the administrative costs of an environmental permit trading system for water quality in Quebec, the Ontario experience (South Nation) has provided useful basic information when making our conclusions. As shown in Table 45, administrative costs in the two Quebec trading systems studied are relatively low.

Table 45 : Examples of Administrative Costs of Two Trading Markets

Trading market	**Average total annual value of transactions (x $1,000)**	**% administrative costs** [(a)]	**Comments**
SCVQ (Quebec) [(b)]	**312,110**	2.9%	This percentage is in relation to all administrative expenses engaged, all of which were not solely used to finance the SCVQ. The SCVQ's administrative costs are thus lower than what is reflected in this percentage. The data used were taken from the 2002-2006 period.
Hog industry auction system (Quebec) [(c)]	**981,504**	0.4%	The administrative costs cover marketing, information dissemination and consultations, as well as the decision-making bodies' operating costs. The data used were taken from the 2002-2006 period.

[a] This percentage represents average administrative costs as a percentage of the total value of quota market transactions. [b] Taken from various annual activity reports of the FPLQ, the Quebec dairy farmers' federation.[66] [c] Taken from various annual activity reports of the FPPQ, the Quebec hog producers' federation.[67]

While Table 45 shows relatively low transaction costs for the auction system, we feel that the permit trading system's administrative costs should be higher because of a number of particular factors:

- Experience (in the United States, the European Union, Australia, etc.) has shown that initial program implementation entails major costs, especially in terms of the various monitoring and verification methods used.
- Effluent monitoring is another factor in higher administrative costs, and the data in this respect need to be completed and updated. The officials responsible for policy implementation will need to ensure that data monitoring, processing and publication are carried out in a transparent and timely manner.

These factors differentiate the administrative costs of the two market-instrument-based policies. However, the documents consulted did not allow us to clearly isolate the specific factors pertaining to administrative costs and/or were not sufficiently up-to-date.[68] The main use of the documents consulted was to establish an order of magnitude for the permit trading system's administrative costs, which were then cross-checked against those of the auction.

Decentralization and Technical Assistance

In most of the programs shown as examples in Table 43 and Table 44 , there is no decentralized activity[69], while the technical assistance apparent in most environmental programs is another factor that has not been taken into account.[70] However, both these factors are bound to increase public transaction costs. The Swiss direct payment system and the U.S.A.'s Conservation Reserve Program (CRP) are two examples of programs in which a certain level of decentralization and/or technical support exists (OECD, 2007). In Switzerland, the transaction costs of decentralized structures represents 2% to 3% of the total compensation paid to producers, since relatively low transaction costs are associated with higher payments. Economies of scale thus seem to exist in decentralized structures. Technical assistance provided

[66] Available at http://www.lait.org/zone3/index5.asp.

[67] Available at http://www.leporcduquebec.qc.ca/fppq/savoir-4_10.html.

[68] See, for example, *South Nation Conservation Clean Water Program. 2005 Annual Report* or Edwards, C. K., *A Market for Emission Reduction Credits in Western Canada* (1999).

[69] However, farm insurance advisors do exist in FAQ's various agencies.

[70] Agri-Environmental Advisory Clubs are used to deliver the Agri-Environmental Support Plan (PAA). These clubs are funded jointly by CDAQ and MAPAQ. However, we are unable to directly link their funding to the various budget headings for the policies examined.

in environmental programs involves guiding producers through two major processes: establishing program eligibility (in terms of land and practices) and determining leasing and payment values. Overall technical assistance expenditures in the CRP remain low at 1% to 4% (Heimlich, 2002, in OECD, 2007).

Public Transaction Costs and Administrative Expenses for Auction and Permit Trading Systems

In light of everything stated above, Table 46 below shows our transaction cost estimates. These estimates are relatively conservative.

TABLE 46 : PUBLIC TRANSACTION AND ADMINISTRATIVE COSTS FOR AUCTION AND PERMIT TRADING SYSTEMS

	Unit	Value
AAFC	% of producer payments	1.7%
MAPAQ	% of producer payments	1.3%
Administrative/financial costs		
Payment policy	% of producer payments	1.7%
Auction system	% of amounts exchanged	0.5%
Permit trading system [(a)]	% of amounts exchanged	4.0%
Monitoring/control (centralized and/or decentralized)		
Payment policy	% of producer payments	3.4%
Auction system	% of amounts exchanged	3.4%
Permit trading system [(b)]	% of amounts exchanged	3.6%
Technical assistance		
Payment policy	% of producer payments	3.0%
Auction system	% of amounts exchanged	5%
Permit trading system	% of amounts exchanged	3.2%

(a) This amount also includes the expenses of setting up the permit trading system (index, tools to assess and select bids, possible extension and education…), even though these are mostly fixed costs. However, because no permit trading system has yet been implemented in Quebec, we have included this cost factor in administrative expenses. We have also assumed that administrative costs are amortized over the program's entire lifespan.

(b) Some of the monitoring/control cost are assumed by the agents that have a legal obligation to reduce pollution. Indeed the public authority also have some monitoring/control costs.

The transaction cost for tradable permits (3.6%) includes the cost of establishing an additional market (index, tools to assess and select bids, possible extension and education, etc.).

Table 44 shows that the expenses associated with the BSE Recovery Program and the special PMWS assistance program for hog farmers (Component 1) come to 1.5% and 1.7%, respectively, of total payments to producers. Since these expenses primarily refer to the financial component, we have chosen them as representative of financial costs. Monitoring costs are estimated at 0.88% in Mexico's PROCAMPO program and 2.6% to 3.4% in Switzerland's decentralized programs (OECD, 2007). We have chosen the higher percentage to ensure sufficiently effective supervision.

Final Comments on the Public Cost of Policy Implementation

In conclusion, it is important to mention that in addition to the differences in transaction cost by policy type, significant variations also exist according to the type of management practices targeted by the policies. OECD (2007) cites the example of Norway where for relatively identical levels of transfers to producers, transaction costs come to 6.8% for conservation tillage and 54% for specialist assistance to particular rural environments. The public transaction cost values that we propose here are therefore average values for the entire target BMPs. It is also important to note that in the case of market-instrument-based policies, the number of producers concerned will be the ultimate determining factor of total transaction costs.

3.2.2.2. One-Time Payment Policies

The design of one-time payment policies implies continued monitoring and oversight activities even after payments to producers are made. The transaction cost headings are thus identical to those for annual payment policies. In a one-time payment context, however, producers are paid in a single disbursement. We can therefore expect administrative costs as a percentage of producer payments to be lower. In fact, we estimate that these will drop from 1.7% to 0.7%. The public transaction cost percentage associated with one-time payment policies thus comes to 10.1%. The difference compared with the annual payment policy would have been greater if the one-time payment policy design had not involved monitoring and controlling BMP implementation over several years.

3.2.2.3. Annual Payment Policies

In light of the preceding information, we estimate that the public costs of implementing annual payment policies would be 11.1% of total payments made to producers. Table 47 provides a breakdown of these costs for the various players involved in implementing the annual payment policy (see the section on policy design).

TABLE 47 : PUBLIC COSTS OF THE ANNUAL PAYMENT POLICY (AS A PERCENTAGE OF TOTAL PRODUCER PAYMENTS)

Public cost of implementation as a % of producer payments	AAFC	MAPAQ	Administration	Monitoring and control	Technical assistance
% of total producer payments	1.7%	1.3%	-	3.4%	3.0%
Cumulated % of public costs	1.7%	3.0%	3.0%	6.4%	9.4%
% of current year's producer payments	-	-	1.7%	-	-
Cumulated % of public costs	-	-	1.7%	1.7%	1.7%

The financial management could be handled by the FAQ, which specializes in managing annual payments (e.g., the FISI program), whereas monitoring and control could be handled by MAPAQ regional offices. The FAQ would thus be responsible for 1.7% of the financial expenses and MAPAQ for 3.4% of the monitoring and control expenses.

3.2.2.4. Mixed One-Time/Annual Payment Policies

We consider that public costs of implementing this policy are the same than the annual payment policy, as this policy presents the higher public costs from both one-time and annual payments policies. We estimate that the public costs of implementing annual payment policies would be 11.1% of total payments made to producers.

3.2.2.5. Market-Based Instruments

The public transaction costs of policies based on an auction system are estimated at 11.9% of the amounts exchanged. In the case of tradable permits, these public transaction costs come to 13.8% of the total value of the amounts exchanged for the Nicolet watershed and 26% for the Little Saskatchewan River. This is due to the increased regulatory challenges in establishing a market in this region. Table 48 shows the main elements that compose these cumulative percentages.

TABLE 48 : PUBLIC COSTS OF MARKET-BASED INSTRUMENTS (AS A PERCENTAGE OF TOTAL TRANSACTIONS)

AUCTION SYSTEM	AAFC	MAPAQ	Administration	Monitoring and control	Technical assistance[71]
Public implementation costs as % of total amounts exchanged	1.7%	1.3%	0.5%	3.4%	5%
Cumulated % of public costs	1.7%	3.0%	3.5%	6.9%	11.9%

TRADABLE PERMITS	AAFC	MAPAQ	Administration	Monitoring and control	Technical assistance
Public implementation costs as % of total amounts exchanged	1.7%	1.3%	4.0%	3.6%	3.2%
Cumulated % of public costs	1.7%	3.0%	7.0%	10.6%	13.8%

Table 49 summarizes the public transaction costs of the various policies studied.

[71] Although the need for technical assistance declines as the program is progressively implemented and as the various players in the marketplace become more experienced, we have kept this cost at the same level.

TABLE 49: PUBLIC TRANSACTION COSTS OF THE VARIOUS POLICIES

Policy	Public transaction costs (% disbursements) (Nicolet)	Public transaction costs (% disbursements) (Little Saskatchewan River)
One-time payments	9.4	9.4
Annual payments	11.1	11.1
Mixed one-time/annual payments	11.1	11.1
Auction system	11.9	11.9
Tradable permit system	13.8	26

Table 49 shows that the highest public transaction costs are for market-instrument-based policies (auction and permit trading systems), followed by the annual payment policy, mixed payment policy and the one-time-payment policy. The transaction costs of the latter are the lowest of all the policies analyzed.

3.2.3. Total Public Costs for all the Policies Considered

Total public costs include both public funding of the various policies (commonly called "the payments") and public transaction costs.

Table 50 shows the findings for each policy analyzed in the context of the Nicolet sub-watershed.

TABLE 50: TOTAL PUBLIC COSTS OF THE VARIOUS POLICIES IN THE NICOLET SUB-WATERSHED

Policy	**Public funding (payments)** (million $)	**Public transaction costs** (% public disbursements)	**Public transaction costs** (million $)	**Total public cost of the policy** (million $)
One-time payments	1.96	9.4%	0.20	**2.16**
Annual payments	5.24	11.1%	0.58	**5.83**
Mixed one-time/annual payments	1.90	11.1%	0.21	**2.11**
Auctions	1.06	11.9%	0.12	**1.18**
Tradable permits (for P only)	0.54	13.8%[72]	0.07	**0.62**

Even with the highest public transaction costs, the market-instrument-based policies (auctions and tradable permits) are the least expensive for government. The tradable permit system policy is the most economical, with public costs totalling $0.62 million; next are auctions, with a total public cost of $1.18 million; the mixed-payments policy comes next, with a total public cost of $2.11 million, followed by the one-time payment policy ($2.16 million). The annual payment policy is the most expensive of the four policies analyzed, with an estimated total public cost of $5.83 million – more than four times higher than that of the auction-based policy.

A study of transaction costs for the ALUS pilot project determined that the transaction costs for ALUS amount to 67%, 22%, and 15% of payments to producers (George Morris Centre, 2008). This are presented as information only, as ALUS is a small pilot project and the costs cannot be compared to those of a larger watershed EG&S program. For this reason, the analysis for the Little Saskatchewan River watershed uses the same estimates as were used in the Quebec case, with the exception of the cap and trade program, which is estimated to be higher for Manitoba.

Table 51 lists the estimated transaction costs of one-time payments, annual payments, auctions and cap and trade programs for the Little Saskatchewan River watershed.

[72] In the case of tradable permits, this rate applies to all payments made under the policy and not just to the government's contribution (75% of payments). However, the total public costs correspond to the sum total of public funding (75% of payments) plus the public transaction costs applied to all payments.

TABLE 51 : TOTAL PUBLIC COSTS OF THE VARIOUS POLICIES IN THE LITTLE SASKATCHEWAN RIVER WATERSHED

Policy	**Public funding (payments)** (million $)	**Public transaction costs** (% public disbursements)	**Public transaction costs** (million $)	**Total public cost of the policy** (million $s)
One-time Payments	2.555	9.4%	0.266	2.821
Annual payments	6.714	11.1%	0.745	7.459
Mixed one-time/annual payments	0.604	11.1%	0.073	0.677
Auctions	0.353	11.9%	0.042	0.394
Tradable permits	0.317	26.0%	0.082	0.400

The differences in estimations of payment levels for cap-and-trade between Manitoba and Quebec are due to the perceived challenges associated with developing a market for phosphorous credits. Water quality cap and trade systems require point sources of pollutants and non-point sources that can be reduced by changing practices. In the Little Saskatchewan River watershed and likely throughout much of Manitoba, the point sources would be industry, large livestock facilities, and municipal wastewater treatment plants. These facilities all require licenses under the Environment Act which stipulate their effluent limits, and these limits typically refer to Biochemical Oxygen Demand (BOD) and not specifically to phosphorous. In order to affect this change and to create a cap for cap and trade, changes in regulations that will affect public costs will be required. The second barrier to the establishment of water quality trading systems is the relative scarcity of point sources due to the fact that the majority of citizens live in Winnipeg.

In general, the analysis for the Little Saskatchewan River watershed revealed that an annual payment delivery policy would be the most expensive form of enticing producers to reduce total P loading to the Little Saskatchewan River by 75% with a cost of $7.4 million. A one-time payment delivery policy would cost $2.8 million, and both auction and cap and trade based systems would cost around $0.4 million While the costs of auctions and cap and trade appear the same based on the assumptions used, there is much greater uncertainty in the estimate for cap and trade, because of the challenges that establishing a market for trading of water quality credits would present. For this reason, the auction based system appears to be the most cost effective option for the Little Saskatchewan River.

It is noteworthy that our estimate for annual payment transaction costs of 11% differ from Dr. Grant's estimates of based on an assessment of the ALUS program (67% of payments for establishment, followed by operating costs of 22% and 15% in subsequent years) (George Morris Centre, 2008). The increased costs of ALUS could be explained by the fact that this is a small-scale pilot project. Had ALUS been a larger undertaking, the percentage of funding for set-up and maintenance would probably have been smaller.

4. MONETARY VALUES OF ENVIRONMENTAL TARGETS

Several methods are used to estimate the economic benefit of environmental goods and natural resources. Among the most commonly used methods are contingent valuation, travel cost and hedonic price. However, these methods engage substantial financial resources and require considerable time. These two drawbacks explain why the benefit transfer method (BTM) has been developed over the last 10 to 15 years.

4.1.1. About the Benefit Transfer Method[73]

Benefit transfer is normally defined as "the transposition of monetary environmental benefit estimates at one site (study site)…to another site (policy site)" (Brouwer, 2000). This entire transposition process needs to meet certain conditions and must take site-specific factors into account.

At this point, it is worth mentioning that Environment Canada initiated a project that led to the development, with the USA's Environmental Protection Agency (EPA), of an inventory of empirical studies on the economic value of environmental benefits and human health effects: the Environmental Valuation Reference Inventory (EVRI).[74] This database is a tool that helps analysts identify existing studies.

The BTM can be applied in different ways depending on particular requirements and available information. Two major categories of BTM use are generally recognized: (1) monetary benefits transfer (statistical or appraised benefits); and (2) benefit models transfer (functions or meta-models). This classification is similar to that adopted by Rosenberger and Loomis (Rosenberger and Loomis, 2003). Whereas benefit transfer uses the result of the relation connecting the population to the reference system's environmental modification, the model transfer system applies this relationship to the system in question. The first category thus involves (i) expert opinion and judgement and (ii) the transfer of statistically-estimated benefits, whereas the second involves (iii) the transposition of estimated functions and (iv) the transfer of meta-models.

[73] Taken from Genty (2005) and Debailleul et al. (2003).
[74] http://www.evri.ca/.

Expert Opinion and Judgement

Expert opinion and judgement is the simplest and oldest transfer technique and is extensively used by the USDA Forest Service. One way in which this approach operates is that a panel of experts is convened to formulate a value (or a range of values) for the environmental modification studied (Willis and Garrod, 1995). Once determined consensually by the experts on the basis of their experience, the benefit in question is then adapted to the system in question. However, this approach is much more complex than it appears, since the panel tacitly draws considerable information from the system in question, some of which cannot be considered in econometric models.

Transfer of Statistically Estimated Benefits

An alternative to expert judgment is the transfer of statistically-estimated values, which consists in evaluating the good in question by directly reusing the value of a similar benefit that has been statistically estimated using a sampling plan (Kask and Shogren, 1994; Bingham et al., 2000; Bonnieux and Rainelli, 2003). The values thus transposed can either be specific values (average, median, or aggregated for the whole population concerned) or form a range (confidence interval, plausible range). Such a transfer only appears valid *a priori* when the system in question is analogous to the reference system in terms of environmental modifications, environmental goods, population, market sizes, substitutes and consumer goods. Nonetheless, the transfer of statistically-estimated values remains a much more transparent method than expert judgment.

Transfer of Estimated Functions

The transfer of estimated functions involves transferring and then applying a given function from one reference study in a way that explains the monetary benefit of the modification evaluated. In concrete terms, functions based on study site data are used in conjunction with the independent variable data from the policy site to measure the value per unit and total units at the policy site. In the case of stated preferences (contingent valuation), the function transferred is a function of surplus – generally, willingness to pay (WTP). In the case of revealed preferences (travel costs, hedonic prices), the function transferred is respectively a function of demand or price (inverse demand). This method is often preferred to the transfer of values because it evaluates the entire function and is thus not limited solely to the data.

Transfer of Meta-Models

A relatively recent alternative method is the transfer of pre-existing or customized meta-models (Sturtevant et al., 1995). A meta-model is developed from a meta-analysis/statistical synthesis of existing studies on a given subject (Van den Bergh et al., 1997; Florax et al., 2002). This method uses a pool of studies to construct models explaining the variability in the results observed in the studies.

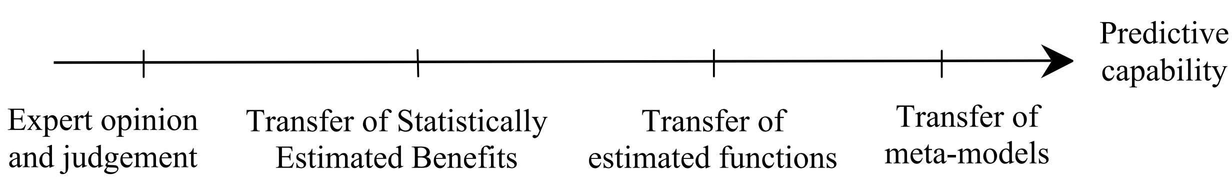
The meta-models transferred are either regression models (quantitative independent variables) or variance analyses (qualitative independent variables) in which the dependent variables are WTP, demand or price, while the independent variables are socio-economic, demographic, specific to the goods and changes envisaged, or associated with other goods (substitutes, current consumption).

Valuation by meta-model transfer then becomes identical to function transfer. It is assumed that the meta-model developed from the reference studies is also applicable to the system in question.

Comparing the Four Benefit Transfer Techniques

Generally speaking, the transfer prediction capability of econometric models is considered superior to that of monetary models because of the diversity of sources used in econometric models and their ability to be more flexible in adapting to the system in question. In this respect, meta-analysis seems to be the best approach, and recommended value transfer seems to be the least effective (see Figure 6).

FIGURE 6 : RANKING THE VARIOUS TRANSFER TECHNIQUES ON THE BASIS OF THEIR PREDICTIVE CAPABILITY



Source: Genty (2005).

Selection of the Technique Used in this Study

Given the higher predictive capability of meta-analysis, this was chosen to evaluate target environmental benefits from an economic standpoint. Use of this method involves the following steps:

- Finding meta-analyses that deal with environmental services comparable to those in this study (water quality and habitat creation/preservation);
- Assessing whether the meta-model is transferable:
  - ⇒ Are the affected populations comparable?
  - ⇒ Do the independent variables make it possible to adapt the estimates in the target site and context?
- Adjust the values of the independent variables to the particular characteristics of both the target site and the study as such.

Limitations and Criticisms of the Benefit Transfer Method

Benefit transfer introduces several uncertainties and inaccuracies through two main underlying sources of error: (i) errors in estimating benefits at the study site and (ii) errors in transferring these estimates to the policy site (Crutchfield et al., 1995). The following types of error occur in estimating benefits at the study site: (i) choosing the wrong form of benefit function, (ii) overlooking significant variables in the benefit function, (iii) inaccurately measuring variables, and (iv) inaccuracies in the random process of providing data. At the same time, other sources of error can affect the calculation of benefits at the policy site: (i) incorrect manipulation of the evaluation function's random components, (ii) errors in totalling the group of independent variable averages and the number of households concerned, and (iii) the size of the market for the environmental service considered.

Furthermore, even when there are relative similarities in environmental goods, their uses and the sites from which they come, this does not necessarily mean that the ultimate benefits are the same. The distribution and characteristics of the population concerned can be different and thus modify the whole process. The same goes for environmental goods that can vary in quality and quantity from one site to the next (Brouwer, 2000).

4.1.2. Methodology

Two studies are used for the transfer of meta-models: Thomassin and Johnston (Thomassin and Johnston, 2008) for surface water quality and Borisova-Kidder (Borisova-Kidder, 2006) for wetlands and terrestrial habitat. All the meta-models estimated by these studies are semi-logarithmic. Specifically, the WTP logarithm by household and by year is estimated on the basis of several variables associated with the study design, the socio-economic context and the resource:

$$ln(WTP) = intercept + \Sigma(coefficient_i)(variable_i) + e \qquad (1)$$

where e represents the error term.

As specified in Thomassin and Johnston (Thomassin and Johnston, 2008), the formula used to estimate WTP is as follows:

$$WTP = exp(intercept + \Sigma(coefficient_i)(variable_i) + \sigma_e^2/2)$$
(2)

where σ_e^2 represents the error term variance. Since the estimated error term variance is not stated in the Borisova-Kidder 2006 study, we deduce it for terrestrial habitat from the estimated WTP of $130.32/acre (see page iii of the study) and our own WTP estimate based on the average values of the independent variables. In the two other cases, surface water quality and wetlands, we hypothesized that the error term variance is the same as the one estimated by Thomassin and Johnston (Thomassin and Johnston, 2008).

In addition to providing a meta-analysis for surface water quality, Thomassin and Johnston (Thomassin and Johnston, 2008) also provide guidelines on how to transfer a meta-model so as to obtain WTP estimates for non-evaluated sites. The two main steps are:

1) Assign values to all independent variables.

As a general rule, methodological variables (the variables that characterize the methodology used in the initial studies) take the average value of the meta-data, except where there are specific reasons for using certain specific values. Conversely, the variables that characterize the resource or socio-economic context are generally the specific ones of the policy and its socio-economic context; and

2) Apply the formula to estimate WTP on the basis of the estimated meta-model coefficients, the chosen values for the independent variables and the estimated error term variance. The calculation of WTP for each model used is explained in detail in Appendix 23, Appendix 24 and Appendix 25.

Monetary Values of Benefits

The meta-models chosen for the monetary evaluation of the target environmental changes estimate respectively the value of a household's WTP to improve surface water quality, the annual value of an acre of wetland, and the annual value of an acre of terrestrial habitat. In the case of models that estimate a lump sum (and not an annual amount), the value of the variable that controls this aspect is chosen in a way that eliminates this option.

Annual unit values are aggregated on two levels: (i) in space, at the level of the target watershed and (ii) in time, over the entire program period (nine years). In the case of water, we hypothesized that improvements in surface water quality are primarily appreciated by the target watershed's inhabitants, even if people living elsewhere can also appreciate such improvements.

For the aggregation over time, it is assumed that all farmers who commit to the policies examined do so in the first year and that as a result, the duration of the program corresponds to the contract period (nine years).[75] This hypothesis simplifies the calculations without necessarily having a major impact on the cost and benefit comparisons. If costs had been calculated in the same way, they would have been slightly higher because of the effect of actualization over a shorter period. A second hypothesis concerning the environmental benefits over time is that each practice achieves its target environmental impact during the first year of its application.[76] Both these hypotheses together have the effect of ensuring that the target levels of EG&S are achieved in each of the nine years of the program.

Before being totalled, the annual benefits are actualized at a rate of 6%, which is the actualization rate generally used for public policies (Montmarquette and Scott, 2007). The same rate has also been used to actualize the payments that the government makes each year under the various policy options considered.

Environmental Changes Subjected to Economic Evaluation

As mentioned at the beginning of this report, the selected EG&S in the present study are surface water quality and wildlife habitat. For surface water quality, the indicator used is phosphorus level, while for habitat, the indicator is the number of ha of woodland and wetland.

Table 52 and Table 53 show the target and reference levels for each of these EG&S by watershed. Whereas the phosphorus concentration objective is more stringent for the Nicolet than for the Little Saskatchewan River (0.036 mg/l and 0.05 mg/l respectively), the reduction is actually much greater in Manitoba because of its higher present concentration (0.20 mg/l in Manitoba compared to 0.041 mg/l in Quebec).The objective for the Nicolet with respect to habitat is to preserve 1,165 ha of existing habitat, while for the Little Saskatchewan River, the goal is to create 550 ha of new habitat. Even if the total

[75] If the initial hypothesis that the last participants leave in the fifth year is maintained, this would complicate the aggregation over time in the sense that the program period would increase to 13 years during which the EG&S will be achieved to varying degrees because farmers do not implement all the proposed practices at the same time.

[76] For most of the practices considered in this study, this hypothesis is relatively close to reality. For example, USDA (2003) states that riparian buffer zones achieve 100% of their impact on the water erosion of soil in their third year of implementation and that cover crops achieve 50% in their first year (USDA 2003, Table 4, page 50). Since phosphorus discharge into watercourses primarily occurs in the form of sediment, a direct link can be made with the effect on phosphorus levels.

habitat conserved is constant across policies, its composition varies. For example, in the Nicolet case, we have 1,165 ha of forests conserved in the case of auctions and no wetland but only 825 ha of forests for the other policies together with 310 ha of wetlands and 30 ha of flooded plains withdrawn from production.

Because the selection of BMPs for phosphorus indirectly covers the objective for habitat in the case of the Little Saskatchewan River (riparian buffers and wetland restoration generate both EG&S: phosphorus reduction and habitat creation), habitat becomes a co-benefit and is often produced in a higher quantity than the 550 ha target. This additional co-benefit is not considered in the analysis because the target is to compare policy costs based on an equal environmental achievement.

TABLE 52 : TARGET AND REFERENCE LEVELS FOR WATER QUALITY, BY WATERSHED

	Nicolet (QC)	Little Saskatchewan River (MB)
Target level	0.036 mg/l	0.05 mg/l
Reference level	0.041 mg/l	0.20 mg/l

TABLE 53 : LEVELS OF HABITAT CREATION AND PRESERVATION, BY WATERSHED

Nicolet (QC) (preservation)			Little Saskatchewan River (MB) (creation)		
Wetland	Woodland	**Total**	Wetland	Woodland / Terrestrial habitat	**Total**
For one-time, annual & mixed payments:			*For one-time & annual payments:*		
340 ha	825 ha	**1,165 ha**	550 ha	0 ha	**550 ha**
For auctions:			*For mixed payments, auctions & tradable permits:*		
0 ha	1,165 ha	**1,165 ha**	0 ha	550 ha	**550 ha**
For tradable permits:			-		
0 ha	0 ha	**0 ha**			

Water Quality

Several meta-analyses have been performed on the benefits associated with improving water quality. These studies include those by Thomassin and Johnston (Thomassin and Johnston, 2008), Borisova-Kidder (Borisova-Kidder, 2006) and Johnston et al. (Johnston et al., 2005). We have chosen the first one for the transfer of meta-models because it allows the estimation of values specific to Canada.

The detailed calculation of WTP is described in Appendix 23. Most of the methodological variables are assigned the average value of the meta-data, whereas the variables relating to the resource and the socio-economic context are the specific values established for the watersheds concerned.

The methodological variables that are evaluated at levels other than the average are: study year, voluntary contributions and lump sum. Voluntary contributions are given the value 0 because only mandatory contributions provide appropriate WTP measurements, while lump sum is set at 0 to ensure that the estimated amounts can be interpreted as annual values. The values of the resource- and context-specific variables are set at the following levels:

a) Income is assigned watershed-specific values in 2002 US$[77] (US$29,971 for the Nicolet and US$22,853 for the Little Saskatchewan. These values are expressed in 2002 US$ because the meta-analysis database is in 2002 US$.

b) The year is fixed at 2002 (code 32 corresponds to the year 2002) because the meta-analysis databases are in 2002 US$.

c) The "number of non-users" variable is valued at 0 to ensure that both resource user categories (users and non-users) are considered in the evaluation.

d) The "multi-region" variable is also valued at 0 to indicate that the study targets a small region, namely, a watershed.

e) The "Canada" variable is given the value 1 to indicate that the target region is found in Canada.

f) The "single lake," "estuary" and "saltwater pond" variables are assigned the value 0 to eliminate valuation of these variables. Meanwhile, the "freshwater" variable is set at 1 to ensure that it is freshwater that is evaluated.

g) The variable indicating a substantial increase in fish population or fishing rates is valued at 0 because this is not one of the changes considered in this study.

h) The water quality reference value and the change in water quality affecting non-specified species are calculated using the Resources for the Future (RFF) Water Quality Ladder, because this is the scale used in Thomassin and Johnston (Thomassin and Johnston, 2008). Appendix 26 shows this scale as well as the water quality index (IQBP – Indice de qualité biologique et physico-chimique de l'eau) used in Quebec. Use of the IQBP is necessary to make the connection between phosphorus levels and water quality as shown on the RFF scale, since the latter scale does not include phosphorus among its parameters.

[77] See Appendix 22 for more information on the specific household income estimates for each watershed. The income is expressed in US$ because it is the currency used in the original model.

It has been necessary to establish equivalents for the four phosphorus levels: 0.03 mg/l, 0.041 mg/l, 0.05 mg/l and 0.2 mg/l. The first two represent the target and reference levels for the Nicolet, and the latter two represent the target and reference levels for the Little Saskatchewan River. In the case of Quebec, the target for both source categories (point and non-point) is considered because environmental benefits can only be envisaged at this level (0.03 mg/l).

The phosphorus concentration of 0.03 mg/l corresponds to Level A (good quality) on the IQBP scale, a level that also assumes fecal coliform numbers of fewer than 200 org/100 ml, dissolved oxygen saturation of 88-124%, biological oxygen demand of less than 1.7 mg/l and a pH of between 6.9 and 8.6. These water quality levels correspond to 9.5 (“drinking”) on the RFF scale. It is therefore assumed that the target 0.03 mg/l is equivalent to 9.5 on the RFF scale. Using the same logic, the 0.041 mg/l and 0.05 mg/l concentrations correspond to level 7 on the RFF scale (“swimming”) and the 0.21 mg/l concentration to 2.5 (“boating”).

Accordingly, the “water quality reference level” for Nicolet is valued at 7 and that for the Little Saskatchewan at 2.5. The “water quality change affecting general habitat” variable is defined as the product of an indicator variable (1 if the general habitat is affected by the change and 0 if only certain species are) and the level of the change according to the RFF water quality scale. Since changes in phosphorus concentrations are considered to affect the general habitat, this variable is assigned the value of 2.5 (1 x 2.5) for Quebec and 4.5 (1 x 4.5) for Manitoba.

Results are presented in Table 54. The monetary value of water quality improvements ranging from level 7 (suitable for swimming) to level 9.5 (suitable for drinking) for a small region like the Nicolet sub-watershed is C$9.8/household/year. The aggregate benefit (actualized) at the level of the watershed over nine years comes to C$1.57 million.

The monetary value per household for the Little Saskatchewan River is much higher than the value for the Nicolet: C$19.34. The difference is mainly due to a much higher improvement of water quality on this watershed (from 2.5 to 7). On the other hand, the aggregated value at the watershed level is much less (0.491 million) because of a much lower population (3,520 households on the Little Saskatchewan and 22,194 on the Nicolet).

TABLE 54 : VALUE OF IMPROVING WATER QUALITY IN THE TWO WATERSHEDS

	Nicolet	Little Saskatchewan River
Value per household per year (2007 C$)	9.8	19.34
Total value for the whole watershed (2007 C$)	1,570,203	490,903

Our estimates are similar to those that Thomassin and Johnston (Thomassin and Johnston, 2008) provide in their study for a hypothetical scenario resembling our study scenarios. Thus, they obtain C$8.66/household/year (in 2002 dollars), whereas our estimate for the Nicolet is C$10/household/year (in 2007 dollars) or $9.16/household/year (in 2002 dollars). The Thomassin and Johnston (Thomassin and Johnston, 2008) scenario assumes that surface water quality is improved by two units, that this improvement affects the general habitat (change in water quality affecting the general habitat = 2), that it appears in several rivers in a small region of Canada (Canada = 1, Multi-regions = 0, Freshwater = 1, Single lake = Estuary = Saltwater pond = 0), and that the water quality reference level is 7 on the RFF scale (water quality reference level = 7). The differences in our scenarios are degree of water quality improvement (2.5 in our case) and income level (the watersheds' average in our case and the meta-data's average in Thomassin and Johnston (Thomassin and Johnston, 2008)).

Olewiler (Olewiler, 2004) gives a value of C$8,500/ha/year for the goods and services provided by the rivers and lakes of the Lower Fraser Valley. To make this estimate comparable with our results, the total length of the watershed's watercourses is transformed into area in ha by assuming that the average width of a watercourse is 3 m. This gives a figure of 212 ha for the Nicolet and 294.6 ha for the Little Saskatchewan River.[78] If the total value of the annual benefits of a water quality improvement[79] is divided by the number of ha, the result is a value of C$1,054/ha/year for the Nicolet and C$243/ha/year for the Little Saskatchewan River watershed. These values are very conservative compared with the one

[78] The total length of Nicolet water courses is 708 km and that of the Little Saskatchewan River is 982 km.
[79] See

Appendix 23 for the value of the WTP/watershed/year (C$217,788 for the Nicolet (East) and C$71,503 for the Little Saskatchewan).

mentioned in Olewiler (Olewiler, 2004), but the difference could be justified by the broader range of EG&S considered in Olewiler (Olewiler, 2004).

Wetlands

As for surface water quality, several meta-analyses have been produced on the benefits associated with wetlands. These include Borisova-Kidder (Borisova-Kidder, 2006), Woodward and Wui (Woodward and Wui, 2001) and Brander et al. (Brander et al., 2003). For the meta-model transfer, we choose Borisova-Kidder (Borisova-Kidder, 2006) because it compares its results with the two others. Among the models considered in this study, we have opted for the one that does not reflect regional differences in the United States because these differences are not relevant to the Canadian context.

The detailed calculation of wetland values in the two watersheds is described in Appendix 24. All the methodological variables are calculated as average values based on the meta-data. The values of the resource- and context-specific variables have been set at the following levels:

a) Income is assigned watershed-specific values[80] (US$34,259 for the Nicolet and US$26,171 for the Little Saskatchewan River). These values are expressed in 2003 US$ because the meta-analysis data base is in 2003 US$.

b) The wetland share is calculated at 2.72% for the Nicolet and 6.4% for the Little Saskatchewan River.[81]

c) The "acre (in)" variable is given the value of 6.73 for the Nicolet and 9.51 for the Little Saskatchewan River. These values correspond to the natural logarithm of the areas of wetland to be conserved (in acres).

d) The "saltwater marsh" and "prairie pothole" variables are valued at 0 for Quebec because these types of wetland are not found in the Nicolet watershed. Freshwater marshes and prairie potholes are found in the Little Saskatchewan River watershed and are therefore valued at 1, while saltwater marshes are not found there.

e) Among the wetland functions, the "water supply" variable is valued at 0 for the Nicolet sub-watershed because no impact is expected on water supply as groundwater is mainly used as a source for drinking water and the selected BMPs are not expected to have an impact on groundwater. The "game fishing" and "commercial fishing" variables are also valued at 0 in the

[80] See Appendix 22 for more information on estimated watershed-specific household income.
[81] This ratio is calculated by dividing the area of wetlands (4,672.31 ha on Nicolet - Del Degan Massé (2008)) by the area of the watershed (172,000 ha for Nicolet – Gangbazo 2005b). For the Little Saskatchewan River, these data are obtained from Manitoba Land Initiative (2007b).

case of the Nicolet because fishing doesn't take place on wetlands but only on the rivers. The "water quality" variable is also valued at 0 in order to avoid double-counting as we already estimate the value of water quality improvement via the Thomassin and Johnston (Thomassin and Johnston, 2008) model.

f) In the case of the Little Saskatchewan River, however, all wetland functions except commercial fishing and water quality are valued at 1.

Wetland benefits thus estimated are shown in Table 55. The annual value of an acre of wetland on the Nicolet is C$173 (C$428 for one ha), and the value of all wetland conserved on the same watershed is C$1.05 million over nine years. In the case of the Little Saskatchewan River, these values come to 4 CA$/acre (9 CA$/ha) and C$0.03 million respectively. The difference between unitary values of the two regions is due to the existence of prairie potholes on the Little Saskatchewan River, which are valued much lower than swamps[82], and the level of income per household which is lower on the Little Saskatchewan River than on the Nicolet. The 9-year value of all the preserved wetlands on the Little Saskatchewan River is lower than the value for the Nicolet in spite of the higher number of ha that are preserved: 550 ha on the Little Saskatchewan River and 340 ha on the Nicolet. The main reason for this difference is the lower unitary value.

TABLE 55 : VALUE OF WETLAND IN THE TWO WATERSHEDS

	Nicolet	Little Saskatchewan River
Annual value per acre of wetland (2007 C$)	173	4
Annual value per hectare of wetland (2007 C$)	428	9
Value over nine years (actualised) of all wetland conserved (2007 C$)	1,050,363	35,523

Our estimates (C$173/acre/year for the Nicolet and C$4/acre/year for the Little Saskatchewan River) are close to those of the Borisova-Kidder (Borisova-Kidder 2006) scenarios, which vary from US$26.77 to US$172.66/acre/year from one region of the United States to another.

Olewiler (Olewiler, 2004) provides annual values per hectare of natural capital for several watersheds in Canada, and its estimates amount to C$195 for the Grand River Watershed, C$66 for the Upper

[82] The coefficient of the dummy variable "Prairie pothole" is -2.526, and the base case is the swamp.

Assiniboine Watershed and C$143 for the Mill River Watershed. These values are close to our estimates for the Nicolet wetlands (C$173/acre).

The literature offers many estimates of the value of wetlands worldwide, which vary greatly from one study to another. For example, the values reported in Turner et al. 2004 (FAO water report 27) range from C$37.97/acre in van Kooten (Kooten, 1993) to C$785/acre[83] in Willis (Willis, 1990). Our estimate for the Nicolet sub-watershed (C$173/acre) adjusts within the previous mentioned range. Another study that reviews estimates of wetland value (Woodward and Wui, 2001) shows an even greater variability of these estimates: they range from US$0.057/acre in Farber (Farber, 1996) to US$13,492/acre in Mullarkey (Mullarkey, 1997). Several studies estimate values over $2,000/acre.

Woodland/Terrestrial Habitat

There are far fewer assessment studies in the literature on terrestrial habitat compared to those on surface water quality and wetlands. The only meta-analysis we found is Borisova-Kidder (Borisova-Kidder, 2006), which formulates a single model on the basis of few independent variables and relatively few (11) original studies.

The detailed calculation of the value of both watersheds' terrestrial habitats is described in Appendix 25. All the methodological variables are calculated on the basis of average meta-data values, whereas the resource- and context-specific variable values are set at the following levels:

a) The "acre (in)" variable is given the value of 7.62 for the Nicolet and 6.99 for the Little Saskatchewan River. These values correspond to the natural logarithm of the areas of terrestrial habitat to be evaluated (in acres).
b) The "wildlife watching" variable is valued at 1 on both watersheds because maintaining and expanding terrestrial habitat is expected to positively contribute to this type of recreation. Because the impact on wildlife is already accounted for via the "wildlife watching" variable, the "open space as habitat for several species" is assigned the value 0. The "open space" variable is also valued at 0 in order to avoid double-counting the impact on wildlife, already accounted for via "wildlife watching".

Woodland benefits thus estimated are shown in Table 56. The annual value of one acre of woodland in the Nicolet is C$121, and the value of all woodland conserved in the same watershed is C$1.78 million over

[83] The study estimates a use-value of £44/ha and a non-use value of £807/ha. We added these two values, transformed the total value per hectare into a total value per acre (1 ha = 2.47 acres) and used the average exchange rate from 1998 to February 2008 to transform UK pounds into Canadian dollars (1 £ = 2.28 C$).

nine years, except for the case of auctions where 1,165 ha are conserved and their value is C$2.51 million. In the case of the Little Saskatchewan River, these values amount to C$260/ha and C$1.032 million respectively. It is worth noting that a unit of woodland is more valuable on the Nicolet than on the Little Saskatchewan River only because the total quantity of preserved woodland is larger. Intuitively, one would argue the contrary: when more ha are conserved, the additional preserved unit is less valuable, just as the utility function increases at a decreasing rate. This result could be justified by a threshold effect: until the level of preservation reaches the environmental beneficial level, each additional unit has a higher value. Once the threshold is reached, the unitary value decreases.

TABLE 56 : MONETARY VALUE OF TERRESTRIAL HABITAT IN THE TWO WATERSHEDS

	Nicolet	Little Saskatchewan River
Annual value per acre of terrestrial habitat (2007 C$)	121	105
Annual value per hectare of terrestrial habitat (2007 C$)	299	260
Value over nine years of total terrestrial habitat conserved (2007 C$)	1,779,756 (for 825 ha) 2,513,231 (for 1,165 ha)	1,032,033

Our estimates correspond to those presented in the Borisova-Kidder (2006) scenarios. We obtain C$121/acre/year for the Nicolet and C$105/acre/year for the Little Saskatchewan, while Borisova-Kidder (Borisova-Kidder, 2006) estimates the value of one acre of terrestrial habitat at US$130.32/year.

Olewiler (Olewiler, 2004) provides annual values per hectare of natural capital for several watersheds in Canada, and its estimates amount to C$195 for the Grand River Watershed, C$66 for the Upper Assiniboine Watershed and C$143 for the Mill River Watershed. These values are lower than our estimates for the two watersheds (C$299/acre and C$260/acre) but are still quite close.

A comprehensive review of forest ecosystem services by the Wilderness Society (Wilderness Society, 2001) that uses Costanza et al. 1997 estimates comes up with a value of US$92/acre (US$220.8/ha) when food production and raw material values are removed. This is also a little bit lower than our estimates but is still very close to them.

5. COST-EFFICIENCY ANALYSIS OF THE DIFFERENT POLICIES

In this section, we analyze the comparison between the evaluation of environmental benefits obtained and the estimated total costs of the policies for the two watersheds, Nicolet and the Little Saskatchewan River. Please note that tradable permits in the Nicolet sub-watershed are only applied to reducing phosphorus concentrations in watercourses and not for creating habitat. Furthermore, water costs in the Little Saskatchewan River watershed include habitat creation costs since BMPs aiming to improve water quality also participate in habitat creation.

5.1. Nicolet Sub-Watershed

Regarding total costs of implementing policies in the Nicolet sub-watershed, the estimated costs of policies based on government payments (annual, one-time and mixed payments policies) are significantly higher than the cost of implementing market-based instrument policies. For both benefits (water quality and habitat creation), annual payments policy costs are more than twice higher than those of one-time payments and five times higher than auctions. Concerning phosphorus reduction only, a policy based on tradable permits has the lowest implementing cost of all policies examined, followed by the auction-based policy, the mixed payments policy, the one-time payments policy and finally the annual payments policy.

TABLE 57 : TOTAL COST OF POLICIES IN NICOLET SUB-WATERSHED (MILLION $)

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits
million $					
Total water costs	1.50	5.25	1.51	0.82	0.62
Total habitat costs	0.67	0.61	0.61	0.37	-
Total costs	**2.17**	**5.85**	**2.11**	**1.19**	**-**

Moreover, in the case of the auction-based policy, the one-time payments policy and the mixed policy, around two-thirds of the estimated total costs go towards reducing phosphorous in the Nicolet watercourses, whereas only one-third is needed to achieve the habitat preservation target. In the case of the annual payments policy, 90% of the costs is used to achieve the target of expected reduction in phosphorous, and only 10% is needed to preserve habitats inside the Nicolet sub-watershed.

Concerning both water and habitat benefits, as shown in table below, habitat benefits are almost twice higher than water benefits. Total water and habitat benefits obtained in the Nicolet sub-watershed are estimated at $4.4 million through all policies, except for the auctions-based policy, where habitat benefits are slightly lower. This could be explained by the fact that the only BMP used for reaching the habitat creation objective through an auction-based policy in the Nicolet sub-watershed is woodland preservation. The estimated value of benefits obtained through "woodland preservation" is slightly lower than benefits obtained through BMPs "wetland preservation" and "removing lands prone to flooding from production". These BMPs are used by government payments policies, together with BMP "woodland preservation", while only the latter is used to create habitat through an auctions-based policy. Habitat creation benefits are thus slightly lower in the auction-based policy case.

TABLE 58 : TOTAL BENEFITS OF POLICIES IN THE NICOLET SUB-WATERSHED

	One-time payments	**Annual payments**	**Mixed one-time/annual payments**	**Auctions**	**Tradable permits** (for P only)
million $					
Water benefits	1.57	1.57	1.57	1.57	1.57
Habitat benefits	2.83	2.83	2.83	2.51	-
Total benefits	4.40	4.40	4.40	4.08	-

Table 59 shows the relationship between the value of environmental benefits obtained and the total cost of the policies in the Nicolet sub-watershed. From the outset, we see that if we consider the total value of the environmental benefits obtained through the various BMPs, except for the annual payments policy, establishing all policies is justified because in every case, the benefit/cost ratio is over 1. The annual payment policy presents a situation in which the total benefits represent only 30% of the costs. Therefore, taken separately, the annual payments policy aimed at achieving water quality is not cost-efficient.

TABLE 59 : BENEFIT-COST RATIOS FOR THE NICOLET SUB-WATERSHED

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits (for P only)
million $					
Benefit/cost ratio - water	1.05	0.30	1.04	1.91	2.53
Benefit/cost ratio - habitat	4.23	4.68	4.68	6.79	-
Benefit-cost ratio – water & habitat	2.03	0.75	2.08	3.43	-

As for habitat creation alone— for which the value of benefits is almost twice as high as that for water quality improvement — net benefits are achieved with every policy analyzed for this environmental benefit.

We can conclude that in the Nicolet case, market-based instruments have the best results in terms of benefit-cost ratios for each environmental benefit as well as for the two benefits considered together. If we consider both benefits (water quality and habitat creation), the auctions-based policy has the best benefit-cost ratio, followed by the mixed policy and the one-time payments policy. The annual payments policy appears to be the least cost-efficient of all policies examined. Concerning water quality only, market-based polices (tradable permits and auctions) are the most cost-efficient policies.

5.2. Little Saskatchewan River Watershed

Regarding total costs of implementing policies in Little Saskatchewan River watershed, annual payments policies have the highest total cost, whereas market-based as well as mixed- and one-time payments policies' costs are lower.

TABLE 60 : TOTAL COST OF POLICIES IN THE LITTLE SASKATCHEWAN RIVER WATERSHED

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits (for P only)
million $					
Total water costs	2.82	7.46	0.68	0.40	0.40
Total habitat costs	0.23	0.29	0.32	0.32	0.32
Total costs*	2.82	7.46	0.68	0.40	0.40

*Total costs are equal to total water costs. Habitat costs are included in water costs as habitat is a co-benefit of the BMPs selected for water

Furthermore, if we look at every environmental benefit separately, one can observe that the same level of water benefits are reached through every policy, while the monetary value of habitat benefits vary among policies even if the total number of ha is identical (see Table 61). This is because the mixed-payment and market-based instruments produce more woodland through riparian buffer zone establishment, which has a higher monetary value than wetlands.

TABLE 61 : TOTAL BENEFITS OF POLICIES IN LITTLE SASKATCHEWAN RIVER WATERSHED

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits (for P only)
million $					
Water benefits	0.49	0.49	0.49	0.49	0.49
Habitat benefits	0.04	0.04	1.03	1.03	1.03
Total benefits	0.53	0.53	1.52	1.52	1.52

Regarding benefit-cost ratios, as in the Nicolet case, market-based instruments are the most cost-efficient for improving water quality (see table below). If we consider both benefits (water quality and habitat creation), the auctions-based policy has the best benefit-cost ratio, followed by tradable permits, mixed payments and far from them, the one-time and the annual payments policies. Once again, the annual payment policy appears to be the least cost-efficient policy of all policies examined.

TABLE 62 : BENEFIT-COST RATIOS FOR THE LITTLE SASKATCHEWAN RIVER WATERSHED

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits (for P only)
million $					
Benefit-cost ratio - water	0.17	0.07	0.72	1.24	1.23
Benefit-cost ratio - habitat	0.16	0.12	3.27	3.25	3.21
Benefit-cost ratio – water & habitat	0.19	0.07	2.24	3.85	3.81

Benefit-cost ratios for one-time and annual payments policies in the Little Saskatchewan River are lower than those of Nicolet, although they are quite similar for the other policies. The lower ratios are mainly due to the lower monetary value of benefits. The ratios for mixed payments and market-based instruments remain almost the same in spite of the lower benefits because the costs of these policies are also lower. The lower monetary value of water quality is explained by the fact that the population of this watershed is lower than that of the Nicolet. The valuation is contingent on people's willingness to pay, so a lower population implies a lower overall willingness to pay. The lower value of habitat is explained by a lower habitat target (550 ha vs. 1 625 ha on the Nicolet) and a lower value per ha (because of a lower revenue and the presence of potholes, in the case of wetlands).

As for the Nicolet case, we can also conclude that policies based on market instruments (tradable permits and auctions) are the most cost-efficient of all policies analyzed, while policies based on government payments seem to be the least cost-efficient.

6. EXTRAPOLATION OF THE COST-EFFICIENCY ANALYSIS TO CANADA

In order to generalize the conclusions of this study for all of Canada, we make an attempt to extrapolate the total public costs of the policies and the monetary environmental benefits potentially generated. Precisely, the costs and benefits estimated for the Nicolet sub-watershed are scaled up at the level of Central and Eastern Canada (Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador), while those for the Little Saskatchewan are scaled up at the level of Western Canada (British Columbia, Alberta, Manitoba and Saskatchewan). Because the necessary data for a detailed extrapolation was not entirely available in the short period of time allocated for this exercise, the results must be carefully interpreted.

6.1. Extrapolation of Costs

The total public costs of the policies considered are scaled up at the level of all agricultural watersheds of the two regions for all BMPs. Ideally, the BMPs that have an impact on water quality should be extrapolated only at the level of agricultural watersheds that present phosphorus problems but because this kind of data is not available in time, we use the larger scale of all agricultural watersheds. As a consequence, total costs are overestimated.

Basically, we first scale-up the payments that agricultural producers receive for adopting targeted BMPs and afterwards apply the % of public transaction cost to estimate total public costs. We use for all BMPs a unitary payment per kg of phosphorus together with the South Nation phosphorus coefficient and the total area of cultivated land or manure. Target adoption rates for water quality BMPs remain the same as those used at the watershed level. As a consequence, we implicitly suppose that the target level of phosphorus is achieved at the level of the two regions at these adoption rates. On the other hand, the target for habitat is re-evaluated at the level of the two regions because it is defined in terms of number of ha. The detailed computations are presented in Appendix 27, after the one-time payments for Central and Eastern Canada.

Several sources of data are used for the scale-up of costs:

1) For water quality BMPs, we use data on crop areas in agricultural watersheds, which are defined as the watersheds that have more than 5% of their area covered by cultivated land. This data is provided by the Agri-Environmental Policy Bureau of Agriculture and Agri-Food Canada.

2) For the manure storage BMP, we use data from the Census of Agriculture 2006 on the number of cattle in Western Canada.

3) For wetland BMPs in Central and Eastern Canada, we use data on the area of wetlands in agricultural watersheds, which are also provided by the Agri-Environmental Policy Bureau of Agriculture and Agri-Food Canada.

4) Finally, for woodland BMPs in Central and Eastern Canada, we use data on the area of forests in agricultural regions of Quebec, compute the percentage of preserved forests on the Nicolet sub-watershed, apply this percentage to the area of forests in Quebec (agricultural regions only) and adjust the area of protected forests for each province as a function of the total area of the province.

A detailed presentation of the scale-up procedure of payments by policy and BMP is available in Appendix 27. The extrapolation is straightforward: we multiply the payment per unit of phosphorus by the total quantity of phosphorus eliminated in all agricultural watersheds and by the expected increase in the adoption rate. The results are presented in Table 63. In Central and Eastern Canada, annual payments remain the most expensive ones with a total of $1,334 million. The general ranking does not change either: market-based mechanisms remain the least expensive instruments for achieving environmental targets ($762 million for auctions) followed by mixed one-time/annual payments ($898 million), one-time payments ($898 million) and annual payments. This ranking remains unchanged for Western Canada, as well as for the whole Canada. In the West, market-based mechanisms are the least expensive ($107 million for tradable permits) followed by mixed one-time/annual payments ($180 million), one-time payments ($4,485 million) and annual payments ($1,175 million).

TABLE 63 : AGGREGATED PAYMENTS FOR CANADA

Central and Eastern Canada (million $)

	One-time payments	Annual payments	Mixed policy	Auctions	Tradable permits
Water quality	613	1,049	613	418	314
Habitat	285	285	285	343	-
Total	**898**	**1,334**	**898**	**762**	**314**

Western Canada (million $)

	One-time payments	Annual payments	Mixed policy	Auctions	Tradable permits
Water quality	485	1,175	180	119	107
Habitat	38	48	54	54	48
Total*	**485**	**1,175**	**180**	**119**	**107**

Canada ($ millions)

Water quality	1,098	2,224	793	537	421
Habitat	323	333	339	397	48
Total	**1,421**	**2,557**	**1,132**	**934**	**469**

*In the case of Western Canada, some BMPs that have an impact on water quality also improve the habitat and there is no BMP specific to habitat that is not taken into account for water quality. This is why total payments equal the payments for water quality improvement.

Total public costs for all policies and both regions, split by environmental objective (water quality and habitat) are summarized in Table 64. These costs show that in both regions and for the whole Canada, the cost of implementing policies based on government payments is significantly higher than the cost of implementing market-based instrument policies. Moreover, efforts required to reach the water quality improvement target are greater than the efforts needed to preserve habitats. These results confirm those obtained at the watershed level.

TABLE 64 : AGGREGATED TOTAL PUBLIC COSTS FOR CANADA

	One-time payments (million $)		Annual payments (million $)		Mixed one-time/annual payments (million $)		Auctions (million $)		Tradable permits (for P only) (million $)	
	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada	Central and Eastern Canada	Western Canada
Total water costs	677	536	1,166	1,306	687	202	477	136	358	123
Total habitat costs	315	43	317	54	319	61	391	62	-	56
Total costs[84]	**992**	**536**	**1,483**	**1,306**	**1,006**	**202**	**868**	**136**	**358**	**123**
	1,528		**2,789**		**1,208**		**1,004**		**481**	

6.2. Extrapolation of Benefits

The benefits scale-up procedure follows exactly the same steps as the monetary evaluation of benefits at the level of the two watersheds. Precisely, we use the meta-models estimated by Thomassin and Johnston (Thomassin and Johnston, 2008) and Borisova-Kidder (Borisova-Kidder, 2006) (presented in Appendix 23, Appendix 24 and Appendix 25) to estimate water quality, wetland and woodland benefits at the level of each province and sum up the results by province to obtain estimates for the two regions. The majority of variables keep the same values as those used at the watershed level, except for variables representing revenue, number of households, ha of woodland and wetland preserved, and the proportion of wetlands in the province.

Water Quality

In the case of water quality benefits, we consider that all households of a province, and not only those living on the watersheds that present phosphorus problems, appreciate the water quality improvement of those watersheds. To compute monetary benefits linked to phosphorus reduction, all data remains identical to the one used at the watershed level, except for the following:

[84] In the case of Western Canada, some BMPs that have an impact on water quality also improve the habitat, and there is no BMP specific to habitat that is not taken into account for water quality. This is why total payments equal the payments for water quality improvement.

1) The revenue variable is given the value of the median household income before taxes of each province. The data comes from Statistics Canada's 2006 Census of Population (Table 111-0009) and is transformed into 2002 US$.

2) The willingness to pay per household is multiplied by the total number of households of the province (from the 2006 Census of Population).

Wetlands

To compute monetary benefits linked to wetland preservation, all data remains identical to the one used at the watershed level, except for the following:

1) The revenue variable is given the value of the median household income before taxes of each province. The data comes from Statistics Canada's 2006 Census of Population (Table 111-0009) and is transformed into 2003 US$.

2) The variable "Proportion of wetland in the region" receives the value specific to all agricultural watersheds of the province. This data is provided by the Agri-Environmental Policy Bureau of Agriculture and Agri-Food Canada.

3) Finally, to compute the value of the variable "Acres (ln)" (acres of wetland preserved - ln) we compute for each of the two watersheds the percentage of preserved wetland from all wetlands of the watershed, consider this percentage as representative for all provinces of the respective region and apply it to the area of wetlands in agricultural watersheds to obtain the area of wetlands to be preserved at the level of each province. The detailed computations are presented in Appendix 27, after the one-time payments for Central and Eastern Canada.

Woodland/Terrestrial Habitat

To compute monetary benefits linked to woodland preservation, all data remains identical to the one used at the watershed level, except for the value of the variable "Acres (ln)" (acres of woodland preserved - ln). As for wetland preservation, (1) we compute for each of the two watersheds the percentage of preserved woodland from all woodlands of the watershed, but because no data is available in time on the area of forests in agricultural watersheds of the two regions, we use this percentage only for the provinces of Quebec and Manitoba respectively to (2) compute the area of preserved woodlands in theses provinces by applying the percentages to Quebec/Manitoba's forests in agricultural regions and (3) adjust the result for the other provinces as a function of their territory compared to Quebec or Manitoba. The detailed computations are presented in Appendix 27 (after the one-time payments for Central and Eastern Canada).

Results

Benefits scale-up results are presented in Table 65. Benefits are estimated at the level of each province and aggregated afterwards for the two regions.

The habitat benefit for Central and Eastern Canada is different for auctions because the composition of this objective is also different. More specifically, the habitat objective is composed of a mix of wetlands and woodlands for one-time payments, annual payments and mixed payments, and it only refers to woodlands for auctions. The composition of the habitat benefit for Western Canada also varies by policy: one-time and annual payments refer to wetlands and all other policies to woodlands. While the composition of the habitat objective is different across policies in both regions, the total number of ha remains constant in order to maintain the same level of habitat preservation.

Water quality benefits are much higher in Central and Eastern Canada ($632 million) than in Western Canada ($273 million). The difference is explained by the total number of households, which is much higher in the east than in the west. Habitat preservation value is even higher in the East ($2,452 million or $3,257 million) than in the west ($17 million or $257 million) because the habitat objective is much higher in the east (1615 ha versus 500 ha), and one unit of habitat is more valuable. These results are similar to those obtained at the watershed level.

TABLE 65 : AGGREGATED BENEFITS FOR CENTRAL & EASTERN CANADA AND WESTERN CANADA

	Central & Eastern Canada	Western Canada
	million $	
	For one-time, annual & mixed payments	For one-time & annual payments
Water quality	**632**	**273**
Habitat (wetland)	**404**	**17**
Habitat (woodland)	**2,048**	**-**
Total	**3,086**	**289**
	For auctions	For mixed payments, auctions and tradable permits
Water quality	**632**	**273**
Habitat (woodland)	**3,257**	**257**
Total	**3,890**	**530**
	For tradable permits	-
Water quality	**632**	
Total	**632**	

6.3. Cost-Efficiency Analysis of the Different Policies

The conclusions generated by the cost-efficiency analysis at the aggregated level of the two regions are very close to those derived from watershed estimations.

Table 66 shows the relationship between the value of environmental benefits obtained and the total cost of the policies in Central and Eastern Canada. If we consider the total value of the environmental benefits obtained through the various BMPs, establishing all these policies is justified because in each case, the benefit-cost ratio is well over 1. This result corresponds to the one obtained at the watershed level except for annual payments, which has a ratio less than one for the Nicolet sub-watershed. This is due to the increase in the benefit-cost ratio for habitat in Central and Eastern Canada.

TABLE 66 : TOTAL BENEFITS, TOTAL COSTS AND BENEFIT-COST RATIOS FOR CENTRAL AND EASTERN CANADA

	One-time payments	Annual payments	Mixed one-time/annual payments	Auctions	Tradable permits (for P only)
million $					
(A) Water benefits	633	633	633	633	633
(B) Habitat benefits	2,453	2,453	2,453	3,257	-
(C) Total benefits (A+B)	3,086	3,086	3,086	3,890	-
million $					
(D) Total water costs	677	1,166	687	477	358
(E) Total habitat costs	315	317	319	391	-
(F) Total costs (D+E)	992	1,483	1,006	868	-
(G) Benefit-cost ratio - water (A/D)	**0.93**	**0.54**	**0.92**	**1.33**	**1.77**
(H) Benefit-cost ratio - habitat (B/E)	**7.79**	**7.74**	**7.69**	**8.33**	**-**
(I) Benefit-cost ratio – water & habitat (C/F)	**3.11**	**2.08**	**3.07**	**4.48**	**-**

The picture varies, however, according to the type of benefit obtained. Therefore, in terms of water quality improvement, only market-based instruments yield net benefits (1.33 for auctions and 1.77 for tradable permits). The benefit-cost ratios for one-time payments, mixed one-time/annual payments and annual payments are less than 1, although very close to 1 for the first two policies (0.93 and 0.92 respectively). Therefore, taken separately, these three policies are not socially profitable when their unique target is water quality improvement. This result is different from the one obtained at the watershed level where only annual payments are not socially desirable. On the other hand, the ratios for one-time and mixed payments only slightly surpass 1 at the watershed level (1.05 and 1.04 respectively), meaning they are very close to those obtained for Central and Eastern Canada.

As for habitat creation — for which the value of benefits is vastly superior to that of water quality improvement — net benefits are achieved with every policy analyzed for this environmental benefit.

Tradable permit policy has the best results in terms of benefit-cost ratios for water quality. If we consider both benefits (water quality and habitat creation), the auction-based policy has the best benefit-cost ratio, followed by the one-time payment policy, mixed policy and annual payment policy, which has the lowest benefit-cost ratio of all policies examined (2.08). This ranking is almost identical to the one estimated for the Nicolet sub-watershed.

The benefit-cost ratios for Western Canada are summarized in Table 67. As in the case of Central and Eastern Canada, market-based instruments have the best results in terms of benefit-cost ratios for water quality, habitat and the two environmental objectives considered together. If we consider both benefits (water quality and habitat creation), tradable permits policy has the highest benefit-cost ratio (4.33), followed by auctions (3.89), mixed payments (2.62) and one-time payments (0.54). The annual payment policy has the lowest benefit-cost ratio of all policies examined (0.22). All these results are similar to those estimated for Little Saskatchewan River.

TABLE 67 : TOTAL BENEFITS, TOTAL COSTS AND BENEFIT-COST RATIOS FOR WESTERN CANADA

	One-time payments	**Annual payments**	**Mixed one-time/annual payments**	**Auctions**	**Tradable permits**
million $					
(A) Water benefits	273	273	273	273	273
(B) Habitat benefits	17	17	257	257	257
(C) Total benefits (A+B)	289	289	530	530	530
million $					
(D) Total water costs	536	1,306	202	136	123
(E) Total habitat costs	43	54	61	62	56
(F) Total costs (D)*	536	1,306	202	136	123
(G) Benefit-cost ratio - water (A/D)	**0.51**	**0.21**	**1.35**	**2.00**	**2.23**
(H) Benefit-cost ratio - habitat (B/E)	**0,39**	**0,31**	**4,23**	**4,16**	**4,62**
(I) Benefit-cost ratio – water & habitat (C/F)	**0,54**	**0,22**	**2,62**	**3,89**	**4,33**

*In the case of Western Canada, some BMPs that have an impact on water quality also improve the habitat, and there is no BMP specific to habitat that is not taken into account for water quality. This is why total payments equal the payments for water quality improvement.

CONCLUSIONS AND RECOMMENDATIONS

The main objective of this study is to provide a comparative cost-efficiency analysis of different policies aiming to produce Environmental Goods and Services (EG&S) through agricultural Best Management Practices (BMPs). The BMPs treated in this report include grassy and wooded riparian buffer zones, winter cover crops, conservation tillage, conversion of marginal farmland to wetland, retirement of flood-prone land, conservation of existing forests and wetland, and manure storage. The policy options analyzed were: annual payments, one-time payments, reverse auctions, and water-quality trading. The cost of implementing these policies has thus been calculated and the EG&S produced have been examined in order to reach the aforementioned objective: to make a cost-efficiency analysis of different policies.

More specifically, the study quantified the costs to producers of certain practices, designed a payment schedule to offset these costs, and estimated public administrative costs. The programs are designed to achieve a target level of two environmental benefits: a reduction of phosphorous concentrations in surface water and the maintenance or enhancement of wildlife habitats. The analysis is conducted for two representative watersheds, the Nicolet (East) sub-watershed in Quebec and the Little Saskatchewan River watershed in Manitoba, and is aggregated to the provincial and national level. The benefits of BMP adoption are given a dollar value through "benefit transfer" methodology. Total public costs of each policy are compared to the benefits in order to obtain benefit-cost ratios. Please note that the numeric results of this cost-efficiency analysis must be carefully interpreted, due to the variability of primary data.

Before we present the results of our study, some background information is needed. Firstly, the design of the policy has an impact on its cost. The set of BMPs selected is the key to the effectiveness of the policy in terms of the EG&S derived relative to their cost. Moreover, certain practices are more cost-effective than others in achieving environmental objectives.

Secondly, the distinction between one-time and annual payment policies is arbitrary, because in theory, an annual payment can always be converted into a one-time payment and vice versa. For a given adoption rate, it is therefore not the method of payment that distinguishes the two programs, but rather the set of BMPs selected. In the case of Quebec, for instance, the cost difference between the one-time and annual payment policies reflects the choice of BMPs and their effectiveness, not the effectiveness of either of the two payment policies per se.

The results show us that a program focused on improvement in water quality, through decreasing phosphorous loadings in water from agricultural sources across Canada to recommended levels, would cost from about $500 million, if delivered through a water quality trading system, to $2.5 billion, if delivered through an annual payment policy. Benefits provided to local populations are worth about $900 million.

A program aiming to increase wildlife habitat in addition to achieving targeted lower phosphorous levels in water at a national scale could be worth between $3.3 billion and $3.9 billion to the inhabitants of the affected regions in terms of improved recreation, drinking water, flood protection, aesthetics and other public benefits. It would cost between $1 billion and $2.8 billion.

Please note that water quality trading cannot be compared to these options because it cannot be used directly to increase wildlife habitat.

With respect to the policies, the results obtained are consistent with economic theory and with the literature. Indeed, policies based on market-based instruments (auctions and permit trading systems) are more effective. Government can get better value than in the case of direct payment policies where there is an asymmetry of information between public policy-makers and producers, who have more information about their preferences, costs and opportunities (knowledge of technology) (Godard, 2006). In addition to that, according to Stoneham et al. (Stoneham et al., 2007), in Australia's experience, market-based instruments (auctions, permit trading systems, etc.) create an economic environment in which agricultural producers are able to make the optimal choice between the production of goods and the creation of EG&S.

However, market-based mechanisms entail higher public transaction costs. Concerning auctions, information problems are resolved as policy-makers inform producers of the environmental impacts of BMPs, and producers, through the bids made, reveal to policy makers the costs of implementing the practices. Auctions make it possible to reduce costs because competition for funding leads producers participating in the program to make bids that are as close as possible to their true costs, rather than seeking to maximize the amount received (Eigenraam et al., 2005). However, an increase in public transaction costs can be expected due to the specific needs associated with the implementation of auction systems: development of a specific environmental diagnostic associated with parcels of land or a set of parcels (Australian approach) or the use of Environmental Benefits Index (U.S. approach).

Permit trading systems are not universally applicable and require that certain conditions be met before they can be implemented. Tradable permits apply only to contaminants regulated through standards that are the subject of legal authorization. BMPs related to biodiversity (wetlands[85] and forest cover) cannot easily be taken into consideration with a permit trading system. Besides, fewer government resources are

[85] The U.S. wetland banking is an example of using tradable permits for creating wetlands.

needed to achieve the objective than with other policies for a given level of EG&S derived, since part of the payments would come from the private sector (point sources).

Transaction costs are also higher than in the case of direct payment policies because there is one more intermediary at the watershed level for the issuance of permits. The amortization of system implementation costs must also be taken into account, which is more complex than in the traditional system of subsidies. The implementations costs can be allocated 1) to the institutional and legal adjustments necessary to make the system work, 2) to the operational mechanisms needed and 3) to the social acceptability of the system. However, the achievement of the target and, therefore, the benefits depends on the growth of point sources in a watershed. Thus, a policy is not likely to be based exclusively on the implementation of a permit trading system to achieve a given objective if a specific time horizon is adopted. It must be integrated with other mechanisms that provide payments for implementing BMPs. It can therefore be designed as a complementary mechanism.

⇒ The following conclusions and recommendations can also be drawn from our analysis :

- Program design will direct the decisions made by the producer in terms of practices to implement and the environmental benefit obtained. The producer will agree to implement the practice only if their opportunity costs are compensated by the policy.
- The cost of the various policies depends on the BMPs selected, on regions where the policy is applied, on geographic scale (watershed level), on selection mechanisms (auctions, tradable permits, others) and on the established payment level.
- One of the possible options for reducing the cost of the policies is to provide guidance to producers on the choice of practices to be implemented. More specifically:
  - ⇒ The most effective BMPs should be prescribed first, until the desired environmental objectives are achieved.
  - ⇒ Relative incentives for specific practices should be determined on the basis of their environmental performance.
  - ⇒ In the case of practices contributing to the achievement of several EG&S at one time, a value should be assigned to each desired environmental benefit.
  - ⇒ However, these solutions presents several disadvantages:
    - → Lacking information on problems that are not solved;
    - → It is a very normative system based on the imposition of one practice to the detriment of another. This could harm technological innovation, since if regulations are very precise, they could make it impossible to achieve the objective by different means. Indeed, technological innovations make it

possible to achieve and even exceed environmental goals at lower costs, in particular by some means that are unknown at the very moment of the implementation of the policy.

- Finally, it is important to adapt environmental objectives and BMPs to the existing context (legal, hydrological, agricultural, etc.). Moreover, programs should be directed toward the achievement of environmental objectives at the watershed level.

FUTURE WORK

The specific BMPs included for selection in a delivery policy can affect the cost of policies. Of the nine scenarios modeled in this study, all but two of them demonstrated a net benefit to society. The two that did not show a net benefit (one-time and annual payments for Western Canada) featured high uptake rates of wetlands. It was shown that wetlands are among the higher-cost BMPs for achieving phosphorous reduction, although they may have significant non-modeled co-benefits. Wetlands were not included in any of the other western scenarios. Altering the BMP portfolios of each policy would yield different benefit-cost ratios. One future area of research would be the optimization of BMP portfolios so that only the most cost-efficient BMPs are included. This would be particularly relevant for the one-time and annual payment policies. For the market-driven policies, portfolio optimization will be done through the market.

In addition to the effects that specific BMPs can have on policy cost, there is also a need to more closely examine the value of environmental benefits provided by BMPs. Placing a dollar value on the benefits of BMPs is challenging. Environmental valuation is an evolving field, and while several veins of valuation methods exist, it remains a challenge to place dollar values on incremental benefits such as those achieved by BMPs. In this study, two methods were used, both of which rely on people's willingness to pay for environmental improvements. While effective at demonstrating that people are willing to pay for environmental improvements, it remains a challenge to value small incremental changes that may not be perceptible. For this reason, more research on valuation needs to be carried out to make more reliable cost-benefit calculations. The objective of this research should be to develop valuation methods for specific environmental parameters (i.e., phosphorous).

This simulation was performed on two sub-watersheds. This study could be expanded to a larger area to determine how things could apply when implemented at a regional scale. This could involve determining priority and target areas shown to be in need of improvement, or where improvements are more cost effective. Exploring a larger area would also allow the model to take advantage of economies of scale to reduce transaction costs.

This study examined five scenarios of EG&S incentive policies. All of the policies are set to induce producers to voluntarily adopt BMPs. An interesting comparison would be to compare BMP incentive policies with other measures such as regulation and enforcement or other wider policy considerations, such as trade liberalizations and marketing boards. All of these factors affect the crops a producer chooses to produce and the methods and practices employed in their production.

Global climate change and the policies implemented by governments to adapt to and mitigate this global phenomenon will have profound impacts on agriculture. Analysis of climate change effects and adaptation policies and how they can affect EG&S provision by farmers will be an important field of study.

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Appendices

Appendix 1

Precisions Pertaining to the Choice of a Representative Watershed for Central and Eastern Canada (Quebec)

Quebec's hydric network consists of 430 watersheds. Some are small and others more substantial. About one hundred watersheds drain areas exceeding 4,000 km² each. In 2002, the new Quebec Water Policy brought integrated watershed-based management to 33 systems prioritized because of degradation. The list of these 33 priority watersheds was our starting point in the process of choosing a watershed to represent the whole Quebec agricultural land base as the backdrop for subsequent analysis. This choice reflected representativeness criteria that will now be outlined in detail.

Objectives and Selection Criteria

In order to compare the costs and benefits of various policies to promote the production of EG&S and identify the ones that can achieve the target EG&S level at the lowest cost, our analysis began with the situation in a representative watershed chosen by pre-established evaluation criteria. These criteria cover:

- Watershed's geographic location
  - ⇒ Only watersheds in major farming regions were considered
- Watershed size
  - ⇒ Watersheds less than 1,500 km^2 were not considered
- Watershed's agricultural value
  - ⇒ More than 30% of the chosen watersheds should be suitable for cultivation.
- Diversity of agricultural practices
  - ⇒ Shown by the watershed's animal density
- Presence of agriculture-related environmental problems
  - ⇒ To produce EG&S, the chosen watershed has to have agriculture-related environmental problems
- Available data
  - ⇒ This criterion is essential if we want to produce an accurate picture and plausible analysis of the territory

Clearly, few watersheds meet all six criteria. Our choice was made through the process of elimination.

Watershed's Geographic Location

Although agriculture is practised in a number of Quebec regions, factors like soil quality, landform and climate mean that some regions offer more agronomic potential than others. The watershed used in our analysis would preferably be located in one of the regions south of the St. Lawrence River, where farming is more significant and diversified. Accordingly, the regions north of the St. Lawrence and their watersheds were excluded. The Montérégie, Chaudière-Appalaches and Centre-du-Québec regions, all south of that river, generate 59% of all agricultural income in Quebec—27%, 18% and 14% respectively (MAPAQ, 2006). For this reason, priority watersheds in these three regions were favoured. These watersheds are:

Region	Watershed
Centre-du-Québec:	- Bécancour - Nicolet
Chaudière-Appalaches:	- Boyer - Chaudière - Etchemin
Montérégie:	- Châteauguay - Aux Brochets-Baie Missisquoi - Richelieu - Yamaska

Some of the above watersheds straddle the U.S. border and thus include areas where Canadian laws cannot require the use of beneficial management practices. This reduces the potential of these watersheds for our analysis.

Watershed Size

Table 68 shows the areas of the above watersheds to the mouths of their respective rivers. Watersheds shown in italics were discarded because they fall short of the minimum 1,500 km^2 area.

TABLE 68 : WATERSHED AREAS TO MOUTH

Watershed	Area to the river 's mouth (km^2)
Aux Brochets-Baie Missisquoi	*661*
Bécancour	2,620
Boyer	*220*
Châteauguay	*1,435*
Chaudière	6,692
Etchemin	*1,466*
Nicolet*	1,721
Nicolet Sud-Ouest*	1,678
Richelieu	23,720
Yamaska	4,784

* The Nicolet River Watershed gets two separate entries because there is no water quality location upstream from the junction of the Nicolet and Nicolet Sud-Ouest Rivers.

Source: Gangbazo et al. (2005b).

Watershed's Agricultural Value

Since they met the first selection criterion, the priority watersheds also meeting the second criterion inevitably show intense agricultural activity. However, only three of the five eligible watersheds meet the cultivable area criterion of more than 30%. The watersheds dropped from our list are italicized in Table 69 below.

TABLE 69 : PERCENTAGES OF CULTIVABLE LAND IN WATERSHEDS (2001)

Watershed	Cultivable area (% of the watershed to the mouth)*
Bécancour	*23.3*
Chaudière	*14.4*
Nicolet	36.9
Nicolet Sud-Ouest	35.2
Richelieu	60.2
Yamaska	46.7

* Land in crops, fallow, or improved/unimproved pasture.

Source: Gangbazo et al. (2005a).

Diversity of Agricultural Practices

As already mentioned, agricultural diversity is shown by animal density: the animals found in a particular watershed divided by the watershed's total area. This factor shows that the watershed is not dominated by animal or plant production but exhibits a degree of diversity in these two major production categories.

Table 70 establishes the animal-density coefficient for the three watersheds meeting all selection criteria thus far. Since we have not defined a set criterion for agricultural diversity, we find that the three watersheds in Table 70 show enough diversity, especially considering the average in the 33 priority watersheds identified by the MDDEP in 2001.

TABLE 70 : ANIMAL DENSITY IN THE SELECTED WATERSHEDS (2001)

Watershed	Animal density (animal units* divided by the watershed area to the mouth [ha])
Nicolet	0.37
Richelieu	0.29
Yamaska	0.68
Average of the 33 priority watersheds	0.18

* An animal unit is the equivalent of one cow, 4.7 breeding swine weighing 20 to 107 kg each or 250 hens, roosters or broilers. Source: Gangbazo et al. (2005a), and our calculations.

Presence of Agriculture-Related Environmental Problems

With integrated watershed-based management, environmental problems clearly reflect the physicochemical properties of waterways, i.e., the watershed's surface water. The bacteriological and physicochemical quality index (BPQI)[86] is generally used to evaluate water quality based on 10 variables: phosphorus, fecal coliforms, cloudiness, suspended solids, ammonia nitrogen, nitrites-nitrates, total chlorophyll "a" (chlorophyll "a" and pheopigments), pH, BOD5 and dissolved oxygen saturation percentage. However, agriculture-related environmental problems are studied mainly in terms of the presence and loading of phosphorus from farmland to waterways.

[86] In French, this is referred to as the Indice de la qualité bactériologique et physicochimique (IQBP); for more detail on this index, consult: http://www.mddep.gouv.qc.ca/eau/sys-image/glossaire2.htm#iqbp.

A number of farms have been enriched by phosphorus in quantities beyond crop requirements so that in some cases, phosphorus levels are critical. Surplus phosphorus may be lost to runoff and thus increase waterway phosphorus concentrations.

Table 71 shows various total phosphorus measurements in the three watersheds that meet all selection criteria thus far. Reviewing the table, we can see appreciable environmental problems with surface-water phosphorus concentrations in these watersheds.

TABLE 71 : WEIGHTED AVERAGE CONCENTRATIONS OF TOTAL PHOSPHORUS

Watershed	Weighted average phosphorus concentrations for the period 2001-2003 (mg/L)
Nicolet	**0.052**
Nicolet Sud-Ouest	0.093
Richelieu	0.034
Yamaska	0.143
Median for the 33 priority watersheds	**0.052**

Source: Gangbazo et al. (2005b).

Ideally, the watershed chosen for our analysis should not have extreme environmental problems linked to phosphorus concentrations. However, the representative watershed cannot have a phosphorus concentration lower than the target of 0.03 mg/L. To argue the representativeness of the environmental problems in the watershed for our analysis, we used median phosphorus concentrations as not influenced by extremes and anomalies.

Table 71 shows the Nicolet sub-watershed as the most representative in terms of phosphorus pollution. The average phosphorus concentration in this sub-watershed is identical to the median of the average concentrations in the 33 priority watersheds. The Yamaska shows phosphorus concentrations dramatically greater than the official target. We are concerned that the introduction of BMPs in this watershed will be unable to create quantifiable EG&S. Moreover the average total phosphorus concentration in the Richelieu River Watershed is too close to the 0.03 mg/L target. This watershed was also identified as one of the watersheds overlapping into the United States; in fact, the Canadian portion is barely 10% of the total area.

Available Data

Though we identified the Nicolet sub-watershed as the most representative of Quebec's agricultural watersheds, the final selection criterion has to be met if we want to complete our analysis.

We are fortunate because the Corporation pour la promotion de l'environnement de la rivière Nicolet (COPERNIC), the agency supporting integrated water management implementation in this watershed, was very willing to share its data. Moreover, painstaking research has already been published as a general description of this watershed environment, including a detailed section on the agri-environment (Ghazal et al., 2006). Other agencies, such as the Union québécoise pour la conservation de la nature (UQCN/Nature Québec) and Ducks Unlimited Canada, have also studied related topics (e.g., wetlands in the Centre-du-Québec region). Therefore, the available data on this watershed will support the rest of our analysis.

Appendix 2

Extended Description of the Nicolet River Watershed

Though the cost analysis for the various BMPs and policies occurs at the Nicolet sub-watershed level, this section describes the whole watershed. This is because information is available at the watershed but not at the sub-watershed level. In our quantitative analyses of the impact of various BMPs on the chosen EG&S, the spatial data will help us separate the information we need on the sub-watershed that interests us.

Territory

The Nicolet River Watershed covers a territory of 3,387.8 km^2 on the south shore of the St. Lawrence River. This territory is covered by three administrative regions (Centre-du-Québec, Chaudière-Appalaches and Estrie) and is under the jurisdiction of eight county municipalities (RCM) and 57 local municipalities.

Appendix 2 shows the natural regions of the Nicolet River Watershed. The Nicolet sub-watershed covers a territory of 1 720 km^2 (Gangbazo, 2005a).

FIGURE 7 : NICOLET RIVER WATERSHED TERRITORY AND NATURAL REGIONS

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Direction du suivi de l'état de l'environnement, MDDEP, décembre 2005.

Source: Ghazal et al. (2006).

The varied landforms of the Nicolet River Watershed sprawl from the St. Lawrence lowlands to the Appalachians. The soils of the lowlands are made up of marine deposits of the Champlain Sea (clay, sand), while the Appalachian ones are mainly glacier deposits (tills) of variable thickness. Watershed elevations range from 15 to 200 m in the lowlands and from 200 to over 600 m in the Appalachians.

In all, there are 20 rivers, 21 brooks and 7 major lakes and reservoirs in the whole watershed. This categorizes our watershed as poor in these surfaces (Ducks Unlimited Canada, 2006). Moreover, free water and wetlands account for only 4.2% of this area (see Figure 8).

The rivers and brooks spring mainly from the Appalachian hills, giving them steeper slopes, and head for the St. Lawrence River. Two main branches make up the watershed: the Nicolet Sud-Ouest and the Nicolet. The latter divides into various branches—the Des Rosiers, Des Pins, Nicolet, and Bulstrode—which, after crossing the physiographic complex of the Victoriaville area, run steep gradients that level off abruptly.

The two (2) major natural lakes in this watershed are Lac Nicolet and the lakes called Les Trois Lacs, which are considered a single body of water. Though Lac Nicolet has an area of 4.1 km^2, it drains a 9.4 km^2 sub-watershed. Its main water supply comes from the underground water, which partly accounts for its health and good water quality. In 2004, an estimated 34% of Lac Nicolet's annual phosphorus loading resulted from human activities on the watershed (Ghazal et al., 2006).

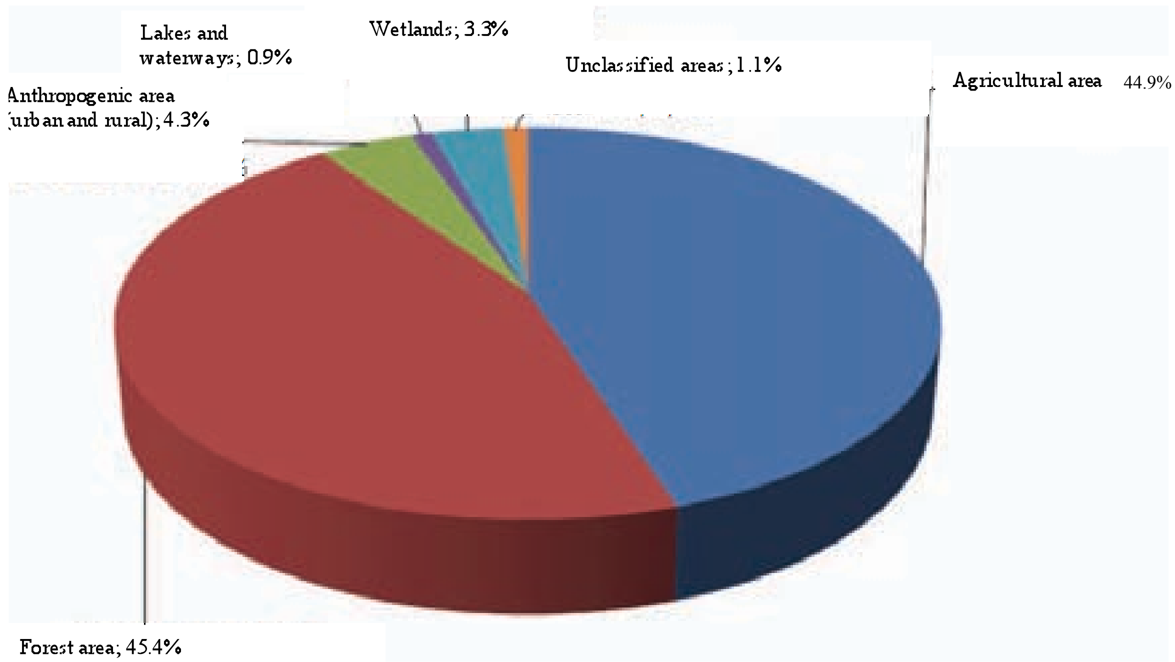
By contrast, the Les Trois Lacs are grappling with pollution problems. In the early 1980s, these lakes apparently received about 20,045 kg of phosphorus a year (Alain, 1981-82 in Ghazal et al., 2006). At that time, barely 8.1% of the phosphorus came from the natural environment.

The countryside in this watershed is forested in the Appalachian hills but becomes a heavily farmed landscape in the St. Lawrence lowlands. Agriculture occupies almost half the watershed's area in the Centre-du-Québec region.

Figure 8 shows the distribution of land uses on the Nicolet River Watershed. We see agriculture claiming nearly 44.9% of its area. Figure 9 shows these uses distributed on the whole watershed.

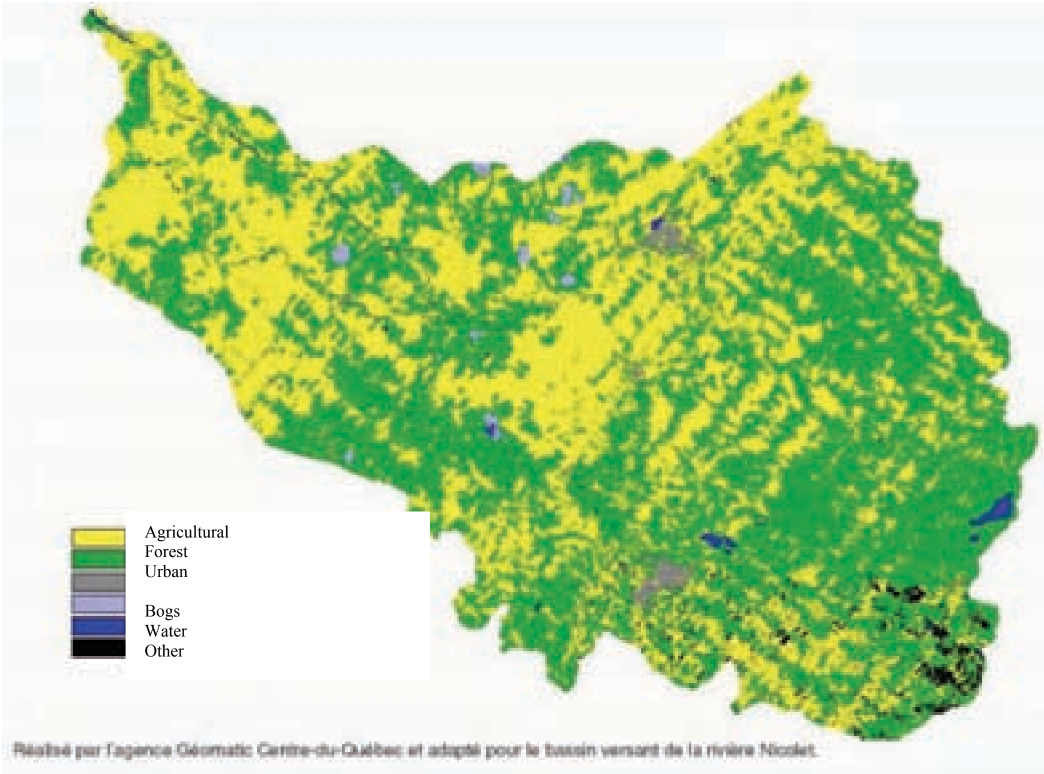
In demographic terms, the population of the Nicolet River Watershed was 96,665 in 2003 (Ministère des Affaires municipales, du Sport et du Loisir du Québec, in Ghazal et al., 2006). In 2006, the watershed had nearly 100,000 residents, with 84% of them (82,364) living in Centre-du-Québec region.

FIGURE 8 : LAND USE ON THE NICOLET WATERSHED



Source: Ducks Unlimited Canada (2006).

FIGURE 9 : FARMLAND DISTRIBUTION ON THE NICOLET WATERSHED



Source: Ghazal et al. (2006).

Agricultural Activity

As shown in Figure 10 and Figure 11 (Appendix 2), the municipalities within the Nicolet River Watershed represent a range of agricultural activity. Generally speaking, cultivated areas are concentrated down the watershed in the Centre-du-Québec region, while animal units are concentrated in the central watershed between the Pins and Rosiers Rivers. Table 72 shows most of the cultivated areas planted in forage crops (49.5%) and field crops, mainly corn (27.8%). According to Table 73, over 90% of the animal units shown in Figure 11 (Appendix 2) are beef cattle and swine. These figures further support our choice of this watershed for analysis: these plant and animal productions also dominate the agricultural sector in Central and Eastern Canada.

Table 74 depicts the development in farm and farmer numbers by age group between 2001 and 2006 in Canada, Quebec and the Centre-du-Québec region. This table shows that the situation in Centre-du-Québec differs little from the other jurisdictions, telling us that the Nicolet sub-watershed is fully representative of Quebec's and Canada's agricultural demographics.

The findings supported by the figures presented in this section are essentially based on the interpretation of data from the 2000 Census of Agriculture published by Statistics Canada in 2001. Though more recent data from the 2006 Census of Agriculture have since been published by Statistics Canada, the rest of our analysis will use the data already compiled and presented in summary papers such as Ghazal et al. (2006) and Gangbazo et al. (Gangbazo et al., 2005a; 2005b).

FIGURE 10 : PERCENTAGE OF CULTIVATED AREA BY SUB-WATERSHED

Source: Ghazal et al. (2006).

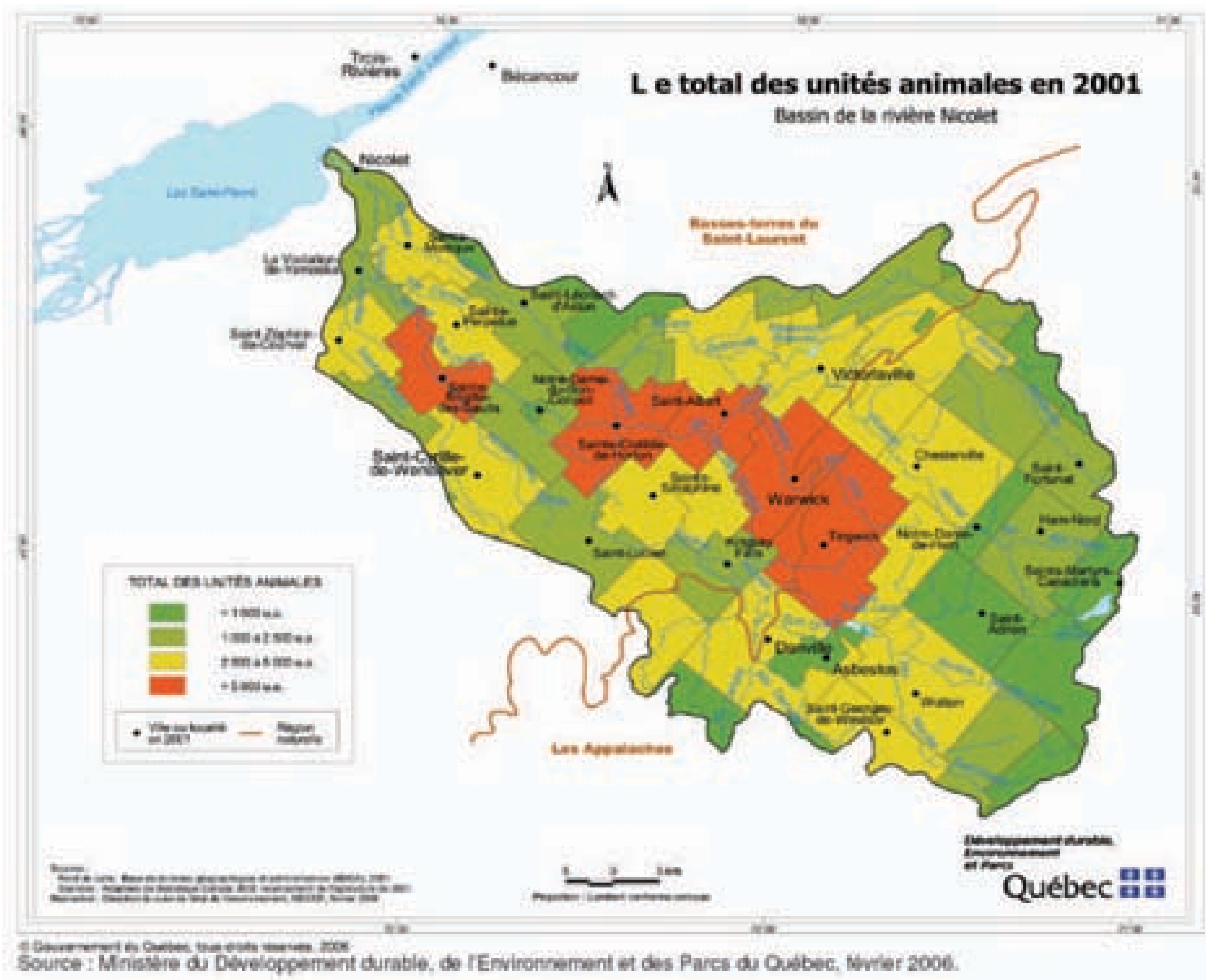
TABLE 72 : CULTIVATED AREAS IN THE WATERSHED

Production	Area (ha)	Percentage (%)
Total wide-row crops[1] Corn[2]	45,381 (33,886)	37.2 (27.8)
Close-row crops[3] Forage[4]	15,398 60,332	12.7 49.5
Other crops[5] Total crops[6]	753 121,864	0.6 100[7]

1. Sunflowers, tobacco, soya, potatoes, sugar beets, large-scale dry beans, legumes, lentils, silage corn, grain corn, sweet corn, large-scale dry peas.
2. Silage corn, grain corn, sweet corn (data included in "total wide-row crops").
3. Mustard seed, flax, mixed grains, barley, buckwheat, rye, triticale, canary grass, oats, wheat, canola.
4. Alfalfa and mixed alfalfa, artificial or seeded pasture, tame hay and other forage crops.
5. Fruit trees, other large-scale crops, safflower, turf, forage seeds, nurseries, fruits, small fruits and nuts, greenhouses.
6. Wide row, close row, forage, other crops.
7. Addition of wide-row crops, forage and other crops.

Source: Statistics Canada (2001) in Ghazal et al. (2006).

FIGURE 11 : ANIMAL UNITS WITHIN THE WATERSHED



Source: Ghazal et al. (2006).

TABLE 73 : ANIMAL UNITS BY PRODUCTION IN THE WATERSHED

Production	Animal unit (A.U.)	Percentage (%)
Cattle	81,354	64.3
Swine	34,406	27.2
Poultry	4,901	3.9
Other	5,762	4.6
TOTAL	126,423	100

Source: Statistics Canada (2001) in Ghazal et al. (2006).

TABLE 74 : NUMBER OF FARMS AND FARMERS BY AGE GROUP

		Canada	Quebec	Centre-du-Québec Region
Total no. of farms	2001	246,923	32,139	3,743
	2006	229,373	30,675	3,448
	Difference 2001-2006	-7%	-5%	-8%
Total no. of farmers	2001	346,200	47,385	5,625
	2006	327,060	45,470	5,275
	Difference 2001-2006	-6%	-4%	-6%
No. of farmers under age 35	2001	14,280	1,670	235
	2006	10,250	1,380	190
	Difference 2001-2006	-28%	-17%	-19%
No. of farmers aged 35 to 54	2001	77,360	10,455	1,150
	2006	64,885	9,135	990
	Difference 2001-2006	-16%	-13%	-14%
No. of farmers aged 55 and over	2001	60,675	6,305	605
	2006	61,375	6,850	640
	Difference 2001-2006	+1%	+9%	+6%

Source: Statistics Canada 2006 Agricultural Census, Data on farms and farmers, catalogue no. 95-629-XWF.

Agri-Environment

Agricultural activity is subject to a number of regulatory requirements in Québec. Appropriate manure storage structures, farm management plans and a minimum riparian buffer strip are examples of these legal obligations. Moreover, a number of voluntary agri-environmental practices have already been adopted by some agricultural producers to curb the negative impact of agricultural activity on local ecosystems. These include various tillage methods, the use of green fertilizers and intercropping, integrated pest management, good water management on farms and fields, crop rotation and buffer zones (Ghazal et al., 2006).

Table 75 below shows that the use of BMP involving different tillage methods, and crop rotation saw positive development between 1996 and 2001.

TABLE 75 : SOIL CONSERVATION PRACTICES ON THE NICOLET RIVER WATERSHED

	Reporting farms (1996)	Reporting farms (2001)	Change (1996-2001)
Total farms	1,891	1,768	-7%
Tillage involving burial of most harvest residues*	**978**	**1,025**	**+6%**
Tillage with most harvest residues on the surface**	**238**	**281**	**+3%**
Cropping without tillage***	112	104	stable
Crop rotation	1,011	1,020	+4%

* - Ploughing
** - Chisel ploughing
*** - Direct seeding
Source: Adapted from Statistics Canada for the Nicolet River Watershed in Ghazal et al. (2006).

The 2003 acceptance rates for various agri-environmental practices by farmers in Centre-du-Québec were:

- Minimal tillage on 41% of areas in annual crops compared with 26% in 1998 (BPR, 2005)
- Intercropping and green fertilizers on 5% of areas in annual crops (BPR, 2005)
- Crop rotation was practised by 54% of farmers owning farms in 1996 and 58% of farmers in 2001 (Statistics Canada, 1996 and 2001).

Implementation of 3-metre buffer zones along waterways in the Nicolet River Watershed is still relatively limited (Ghazal et al., 2006). In 2003, 51% of Centre-du-Québec farming enterprises crossed by waterways maintained 3-metre buffer zones, while 92% of these enterprises maintained 1-metre buffer zones (BPR, 2005 in Ghazal et al., 2006).

Table 76 shows reporting farms with riparian buffer strips and windbreaks in 1996 and 2001. We find these percentages changing slowly. In 2003, only 2% of areas in annual crops were protected by windbreaks in Centre-du-Québec (BPR, 2005).

TABLE 76 : FARMS WITH RIPARIAN BUFFER STRIPS AND WINDBREAKS

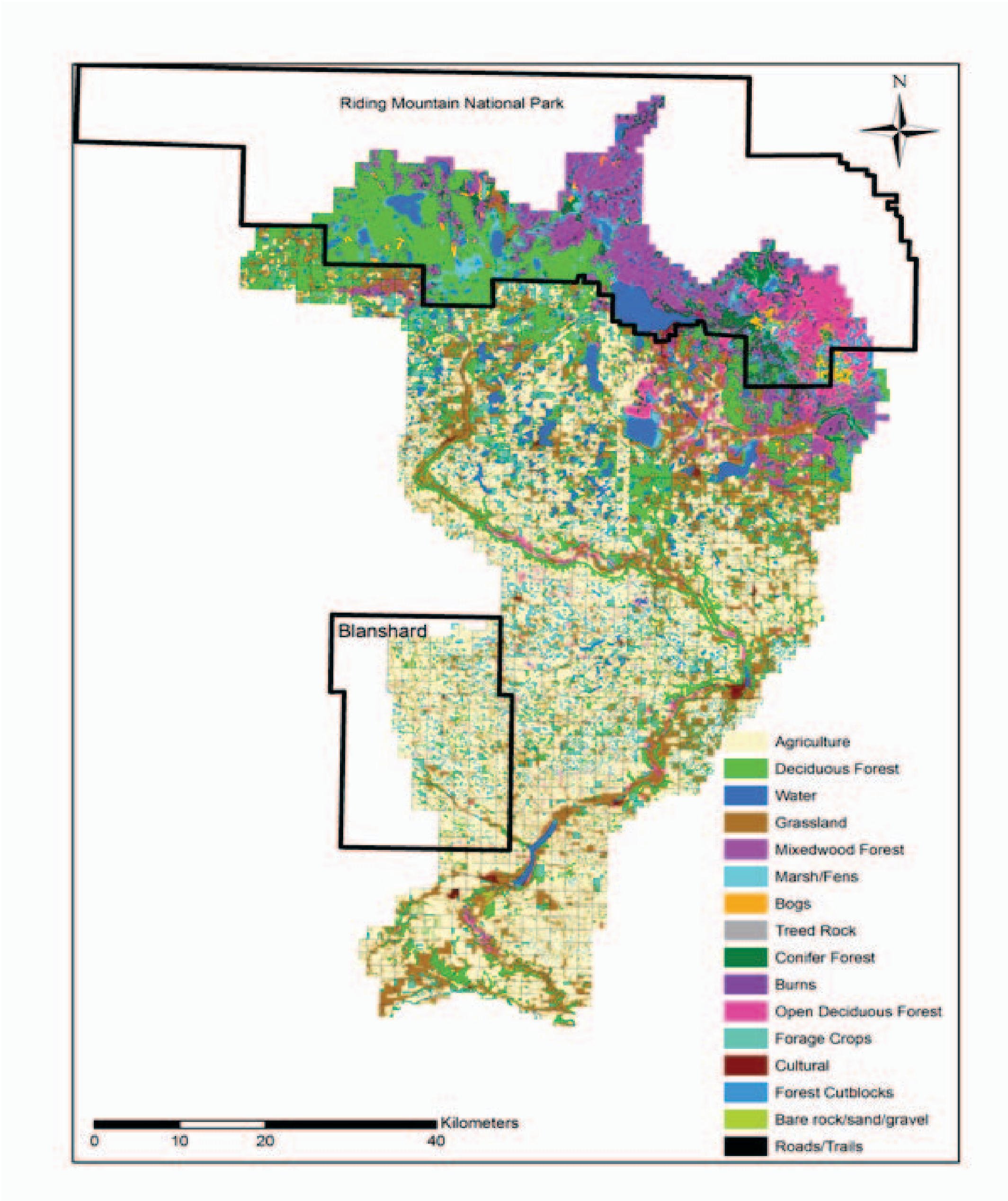
	Reporting farms (1996)	Reporting farms (2001)	Change (1996-2001)
Total farms	1,891	1,768	-7%
Herbaceous strips	35 (1.9%)	99 (5.6%)	+3%
Windbreaks	76 (4.0%)	107 (6.1%)	+2%

Source: Adapted from Statistics Canada for the Nicolet River Watershed in Ghazal et al. (2006).

Appendix 3

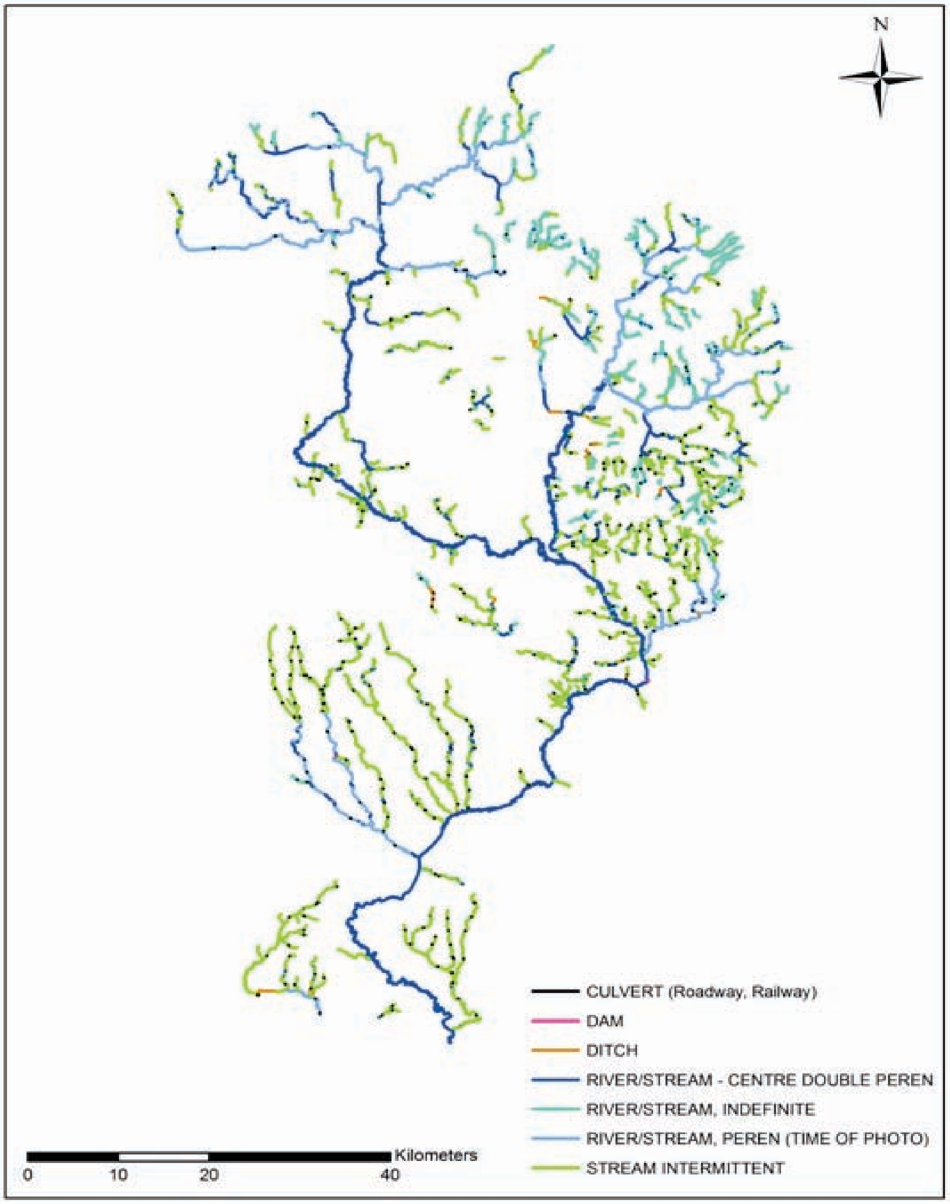
Maps on the Little Saskatchewan River Watershed

FIGURE 12 : LAND USE IN LITTLE SASKATCHEWAN RIVER WATERSHED



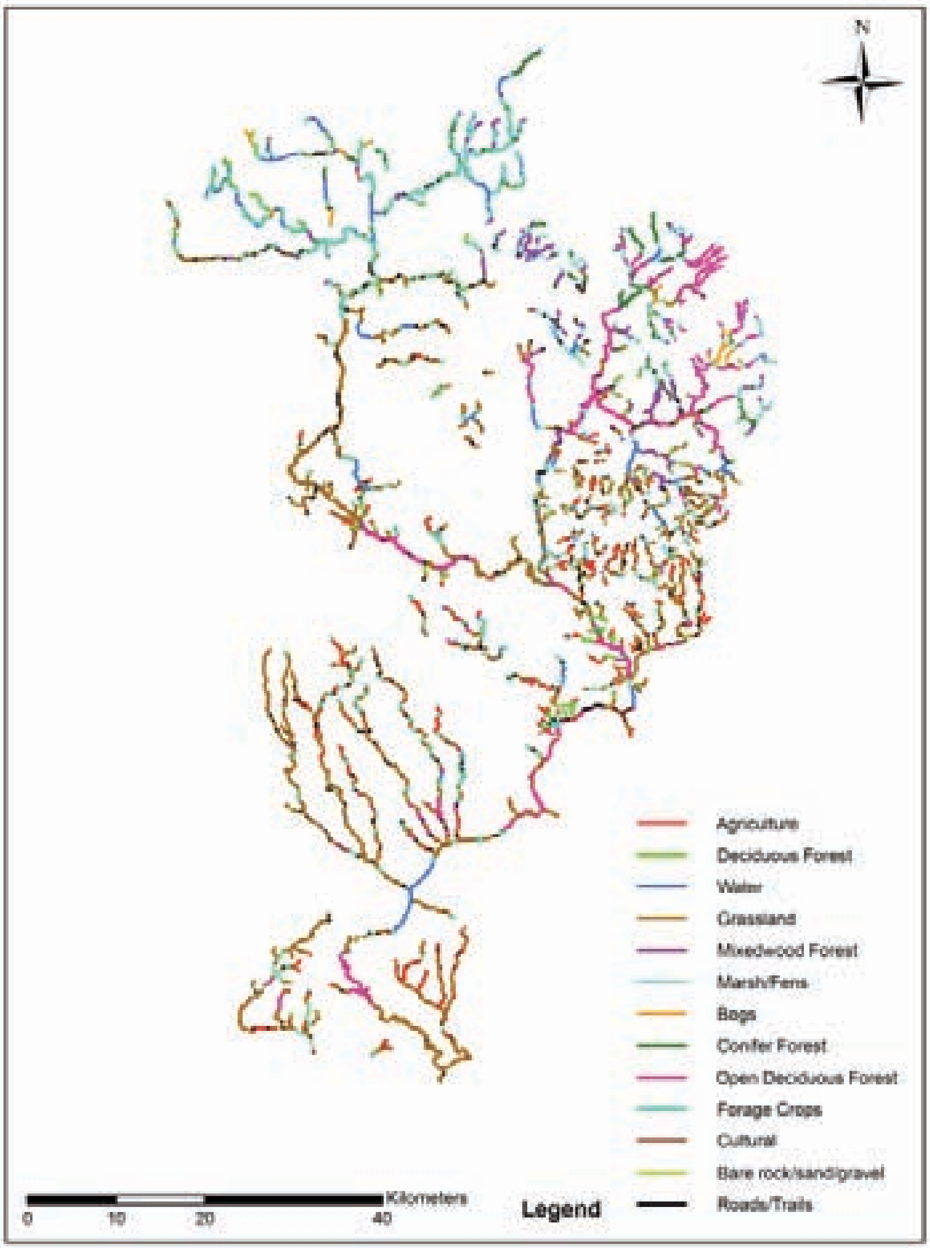
Source: Manitoba Land Initiative (2007a).

FIGURE 13 : DISTRIBUTION OF WATERCOURSES IN LITTLE SASKATCHEWAN RIVER WATERSHED



Source: Manitoba Land Initiative (2007b).

FIGURE 14 : LAND USE OF LITTLE SASKATCHEWAN RIVER WATERSHED RIPARIAN AREAS



Source: Manitoba Land Initiative (2007a, 2007b).

Appendix 4

Details Regarding Choosing Priority EG&S for Analysis

This section identifies a number of priority EG&S. Table 77, from Swinton and Zhang (2005), presents an extensive list of EG&S cited in the literature by various writers. This list includes 27 EG&S categorized by the ecosystemic functions they support. A glance reveals some EG&S, including crop pollination and climate control, garner unanimous support, while others, including ecosystemic resistance to invasive species, are cited by only one or two authors.

TABLE 77 : ECOLOGICAL GOODS AND SERVICES RECOGNIZED IN THE LITERATURE, COMPILED BY SWINTON AND ZHANG (2005)

	Daily (1997)	Constanza et al. (1997)	ESA	ESP	EcoValue Project	De Groot et al. 2002)	Firth (2004)
Regulation functions	▪	▪	▪	▪	▪	▪	▪
1 Purification of air	x		x			x	x
2 Climate regulation	x	x	x	x	x	x	x
3 Regulation of atmospheric chemistry		X			x	x	x
4 Protection from the sun's harmful UV radiation	x		x			x	x
5 Regulation of river flows and groundwater levels	x	X	x	x	x	x	x
6 Water supply		X			x	x	
7 Purification of oceanic chemistry	x		x	x		(1)	x
8 Regulation of oceanic chemistry							x
9 Soil formation	x	X	x		x	x	
10 Renewal of soil fertility	x		x	x		x	x
11 Erosion control		X	x	x	x	x	x
12 Nutrient regulations and storage	x	X	x		x	x	x
13 Dispersal of seeds	x		x				
14 Waste absorption and breakdown	x	X	x		x	x	x
15 Disease control (Regulate disease carrying organisms)			x			x	x
16 Pollination of crops and natural vegetation	x	X	x	x	x	x	x

	Daily (1997)	Constanza et al. (1997)	ESA	ESP	EcoValue Project	De Groot et al. 2002)	Firth (2004)
17 Ecosystem resistance to invasive species							x
18 Biological control of pests and pathogens	x	X	x	x		x	x
Habitat Functions							
19 Provision of shade and shelter			x				
20 Provision of habitat for various organisms		X		x	x	x	
Production Functions							
21 Production of food, fibre, turf and fuel		X				x	x
22 Maintenance of biodiversity and generic resources	x	X	x	x		x	x
23 Medicinal resources						x	
24 Ornamental resources						x	
Information functions							
25 Aesthetic and spiritual amenities	x			x	x	x	
26 Recreation		X			x	x	
27 Support of diverse human cultures	x	X		x		x	

Source: Swinton and Zhang (2005).

Based on Table 77, we were able to identify the EG&S most likely to be influenced by agri-environmental measures. These EG&S are listed in Table 78 for different components of the natural and social environment. Undoubtedly, BMPs directly or indirectly generate a substantial number of EG&S. It thus becomes necessary to identify the EG&S that will be priorities for achieving the objectives of this study.

TABLE 78 : EG&S LIKELY TO BE GENERATED BY VARIOUS BMPS

Component	EG&S
Soil	Conservation/restoration of soil physical structure Conservation/restoration of soil biochemical composition Conservation/restoration of soil biodiversity
Water	Conservation/restoration of water physical quality Conservation/restoration of water biochemical quality Conservation/restoration of moisture balance Conservation/restoration of biodiversity in wetlands and aquatic environments Control of household and industrial wastes

Air	Conservation/restoration of air quality
	  Reducing odour and dust
	  Controlling the chemical properties of air
	Climate control
	  GHG reduction
	  Carbon storage
	  Creation of favourable microclimates

Biodiversity	Habitat creation Control of diseases and invasions by exotic species Improved pollination of harvests and natural vegetation Conservation/restoration of vulnerable and threatened species and populations
Social	Conservation/restoration of recreational environments Landscape protection Respect for and conservation of cultural specificities

Selection criteria were immediately defined to earmark EG&S for analysis. The EG&S in Table 78 were tested using the following criteria:

1. Quantifiable biophysical change:
   ⇒ EG&S where biophysical change is hard to quantify were eliminated.
2. Non-marginal biophysical change:
   ⇒ EG&S showing insignificant biophysical change generated by BMPs were eliminated.
3. Perceptible public impact:
   ⇒ EG&S that people cannot perceive (such as conserving soil biochemical structure) were eliminated. This criterion will mainly be used to facilitate the allocation of a monetary value to each EG&S.

The selection process was based on available information. Without downplaying the importance of the rejected EG&S, it seems that a number of the EG&S in Table 78 represent substantial challenges in measurement terms, i.e., evaluating the impact of BMPs on target EG&S levels. In view of the technical, scientific and time constraints we are dealing with in this project, we identified EG&S that can be part of a monitoring campaign and associated with existing data. Given these selection criteria, preserving biochemical water quality and creating wildlife habitat (wetland and woodland) were identified as our priority EG&S. The whole process of eliminating EG&S based on each of these criteria is outlined below. There follows a description of the indicators used to analyze the impact of BMPs on prioritized EG&S.

Quantifiable Biophysical Change

Immediately eliminated were EG&S for which we have no recognized evaluation process and/or where the information needed to measure change is unavailable or insufficient. A number of the EG&S listed in Table 78 are hard to quantify. Though technically feasible, the quantification of factors associated with other EG&S is unlikely to be completed for analysis within a reasonable time. Some of these data are quantifiable but not compiled and are thus unavailable at the watershed level. We are therefore rejecting the following EG&S for the purposes of our analysis.

- Conservation/restoration of soil biodiversity
- Control of diseases and invasions by exotic species
- Improved pollination of harvests and natural vegetation
- Conservation/restoration of air quality
- Climate control

Changes caused by carbon storage and EG&S connected with GHG reduction seem to be strongly emphasized by society as a result of media exposure and climate change policies. The Chicago Climate Exchange (CCX) has developed a methodology with standardized rules for selling carbon credits. BMPs eligible for this kind of transaction include conservation tillage and grassland conversion.[87] Tillage BMPs can thus generate private benefits for farmers and public benefits for society. However, although numerous quantification protocols have been defined, it has not yet been established how carbon sequestration levels need to be measured in Canada.

[87] For further details, see http://www.chicagoclimatex.com/content.jsf?id=781.

Non-Marginal Biophysical Change

EG&S are marginal when the biophysical change caused by a beneficial agricultural management practice is insignificant. This second selection criterion will eliminate marginal EG&S. We thus reject the following EG&S, which will be excluded from the ongoing project.

- Control of household and industrial wastes
  ⇒ This EG&S refers mainly to waste treatment techniques using plant materials. Several Canadian jurisdictions heavily regulate the reclamation of household and industrial wastes anywhere near food intended for human or animal consumption. In our view, the implementation of waste treatment techniques goes far beyond the purview of this study.
- Respect for and conservation of cultural specificities
  ⇒ The protection of historic sites and certain areas is not the purview of beneficial agri-environmental management practices. Other measures are more effective for this purpose.

Perceptible Public Impact

This selection criterion introduces the public perception of goods and services. For example, the “conservation/restoration of soil biochemical structure”, which refers to the maintenance or the improvement of the fertilizing potential of soils while maintaining the quality of water, air and soil, generally escapes public notice, though it is noticed by farm producers who have to spread organic and mineral fertilizers on their land to maintain fertility. On the other hand, the “conservation/restoration of biochemical water quality” EG&S will normally be more noticeable to the public through private wells, boil-water warnings, odour, taste, etc. This third criterion enables us to eliminate the following EG&S identified as unperceivable by society:

- Conservation/restoration of soil physical structure
- Conservation/restoration of soil biochemical structure

Analytical Results and Parameters

Eliminating the EG&S seen as non-priority using the three selection criteria described above leaves us with the following EG&S as the focus of our analysis.

- Conservation/restoration of physical water quality

- Conservation/restoration of biochemical water quality
- Conservation/restoration of moisture balance
- Conservation/restoration of biodiversity in wetlands and aquatic environments
- Habitat creation
- Conservation/restoration of recreational environments
- Landscape protection

Clearly, the EG&S listed above are associated with various types of social uses. Relatively readily quantifiable, significantly influenced by the introduction of BMPs and perceptible by the public, these EG&S are seen as priorities for our analytical purpose.

In conclusion, the priority EG&S identified are quantifiable at the biophysical level, the biophysical change is significant and is publicly perceivable. In view of the fairly short length of this mandate and the absence of data on all prioritized EG&S, we chose biochemical water quality and habitat creation. Biochemical water quality will be evaluated by the total phosphorus (TP) concentration (in mg/L) and habitat creation by wetland and woodland areas (in ha). The table below summarizes these choices:

TABLE 79 : PRIORITY EG&S CHOSEN FOR THIS STUDY AND MEASUREMENT PARAMETERS

Priority EG&S chosen for this study	Parameter
Conservation/restoration of biochemical water quality	- Phosphorus concentration in water
Habitat creation	- Wetland areas - Woodland areas

Phosphorus Concentration in Water

Total phosphorus in surface water has long been seen as a good indicator of nutrient enrichment in these environments. Only a small portion of the phosphorus in soil is absorbed by plants and other organisms. Another portion is taken to waterways by runoff. Though part of a natural cycle, phosphorus is now in surplus in a number of worldwide aquatic environments, causing numerous surface-water eutrophication problems (algae blooms, massive aquatic plant growth, oxygen deficit, bad odours, fish mortality, etc.).

In Quebec, agricultural activity is often cited as the main cause of exceeding environmental criteria for phosphorus concentration in water. A number of studies have established a link between concentration above 0.05 mg/L of phosphorus in water bodies and heavily cultivated or/and high animal-density areas in a watershed (MDDEP, 2002).

Phosphorus concentrations are effective indicators inasmuch as they are measured on a regular basis. In Quebec, the Environment ministry (MDDEP) maintains a network of water quality monitoring stations, the Réseau-rivières, to follow the state of and changes in surface-water quality. This information is used to build a water quality index, the IQPB, based on the bacteriological and physicochemical quality of a river or water body. Apart from phosphorus, this index is based on various water-quality parameters such as fecal coliforms, turbidity, suspended solids, ammonia nitrites-nitrates, chlorophyll “a”, pH, BOD5 and oxygen saturation.

In Western Canada, Lake Winnipeg water-quality concerns signal the presence of a similar problem. At 24,400 km², this is the sixth-biggest freshwater lake in Canada, being part of Alberta, Saskatchewan, Manitoba, Northwestern Ontario and four American states. According to the Manitoba government, excessive nitrogen and phosphorus loadings in Lake Winnipeg are causing a gradual change in water and ecosystem quality. These changes are directly associated with the growth of harmful algae affecting fish habitat and thus fishing, other recreational pursuits, and access to potable water (Lake Winnipeg Stewardship Board, 2006).

In 2003, as part of a plan to clean up the lake, the Manitoba government announced its intention to cut nitrogen and phosphorus loading in Lake Winnipeg, mainly by going after non-point sources upstream in the watershed.[88]

In analyzing policies for the effective use of certain BMPs to improve the general condition of the environment and ecosystems, the use of this parameter (total phosphorus concentration in water) will very likely favour longer-term policies. Because this element is heavily stored in soils, reductions cannot be measured and reported in the shorter term. Moreover, reducing phosphorus in water may potentially have indirect beneficial effects on other water-quality parameters such as cloudiness and suspended solids.

[88] Lake Winnipeg Action Plan:
http://www.gov.mb.ca/waterstewardship/water_quality/lake_winnipeg/action_plan.html.

Wetland Areas

Wetlands (marshes, swamps, seasonal ponds and peat bogs) attract a variety of wildlife including a number of species of ducks, herons, muskrats and various kinds of turtles and fish, as well as salamanders and frogs. Wetlands are inhabited by various rare or threatened species. Their diversity of plant life, extent and depth make them indicators of environmental quality (Environment Canada, 2006). According to Environment Canada, their degradation and disappearance entail ecosystem losses and a negative impact on humans with whom they are closely linked. Indeed, wetlands play a role no other ecosystem can fill in terms of natural water-filtration capacity. When water passes through these environments, its surplus nutrients and pollutants are absorbed and/or degraded by plants, bacteria and soil. By absorbing these substances, wetlands not only improve water quality but also play a role in the recycling process for nutrients like nitrogen and phosphorus.

Wetlands also offer numerous socio-economic benefits inasmuch as they can bring economic spin-offs for adjacent communities through ecotourism. Wetlands are also of great interest for scientific research. Our use of this parameter in analyzing policies for the effective use of certain BMPs will promote economic development and the conservation of environmental biodiversity.

Woodland Areas

A number of EG&S are associated with forests. They provide habitat for a number of species of flora and fauna, including some that are rare or threatened. This makes them essential for maintaining biological diversity.

In the agri-environment, they can act as windbreaks to reduce wind erosion of soil. They also reduce surface runoff and the water erosion of soil, which improves water quality by reducing fertilizer and suspended-solid loadings. Furthermore, forests greatly assist groundwater replenishment.

Woodlands also play a socio-economic role by contributing to scenery quality and supporting tourism.

Appendix 5

Share of Agriculture to the 0.030 mg/L Phosphorus Target Concentration on the Nicolet sub-Watershed[89]

Non-point phosphorus loadings (t/year)	(A)	27.8
Point phosphorus loadings (t/year)	(B)	10.4
Natural phosphorus loadings (t/year)	(C)	10.9
TOTAL	(D) = A+B+C	49.1
Sources having a potential for reduction (point + non-point)	(E) = A+B	38.2
Share of non-point sources (agriculture)	(F) = A/E	**73%**
Target concentration (mg/L)	(G)	0.030
Flow (hm^3/year)	(H)	937
Target phosphorus loadings (t/year)	(I) = G*H	28.1
Current phosphorus loadings (t/year)	(J)	49.1
Target reduction (t/year)	(K) = I - J	21.0
Share of agriculture (t/year)	(L) = K * F	15.2
Phosphorus loadings after agriculture reductions are accomplished (t/year)	(M) = J - L	33.8
Target concentration for agriculture	(N) = M/H	**0.036**

[89] Based on data published in Gangbazo 2005b (Table 4.3).

Appendix 6

Baseline Concentration of Phosphorus on the Nicolet sub-Watershed (0.041 mg/L)[90]

Livestock access to water[91]

Target level of uptake	(A)	85%
% of farms with rangelands next to watercourses[92]	(B)	33%
# of dairy cows[93]	(C)	16,438
# of dairy cows with potential access to watercourses	(D) = B * C[94]	5,425
# of beef cattle[95]	(E)	5,184
# of beef cattle with potential access to watercourses	(F) = B * E[96]	1,711
% of dairy cows having access to watercourses among those with a potential access (in 2003)[97]	(G)	30%
% of beef cattle having access to watercourses among those with a potential access (in 2003)[98]	(H)	62%
# of dairy cows with access to watercourses - target	(I) = A * D	4,611
# of beef cattle with access to watercourses - target	(J) = A * F	1,464
# of dairy cows with access to watercourses – in 2003	(K) = G * D	1,627
# of beef cattle with access to watercourses – in 2003	(L) = H * F	1,061
# of dairy cows with access to watercourses – additional	(M) = I – K	2,983
# of beef cattle with access to watercourses – additional	(N) = J – L	393
% of manure that reaches the watercourse[99]	(O)	3%
# of days spent outside (within a year)[100]	(P)	184
% of a day spent inside because of milking	(R)	50%
Quantity of phosphorus in manure – dairy cows (kg P/day)[101]	(S)	0,142

[90] Among the phosphorus BMPs listed by South Nation Authority (2003), five are already regulated in Quebec: milkhouse wastewater, livestock access to watercourses, 3 m wide riparian buffer zones, manure storage facilities and nutrient management. Because the last two already have high levels of uptake in 2003, we only estimate the impact at 85% of milkhouse wastewater, livestock access to watercourses and 3 m wide riparian buffer zones. The "Plan agroenvironnemental de fertilization (PAEF)" has already been adopted by 76% of agricultural producers of Centre-du-Québec in 2003 (BPR 2005, Table B.1), while manure storage by 78% (BPR 2005, Table B.2).
[91] We assume that in Quebec, mainly cattle have potential access to watercourses.
[92] Computed from the data base of the 2006 Farm Environmental Management Survey for the Quebec eco-region of St. Lawrence Lowlands.
[93] Computed from the 2006 Census of Agriculture data for municipalities that have more than 50% of their area inside the Nicolet sub-watershed.
[94] We implicitly suppose that all farms have the same number of animals, so that the % applied to the number of farms may also be applied to the number of animals.
[95] Computed from the 2006 Census of Agriculture data for municipalities that have more than 50% of their area inside the Nicolet sub-watershed.
[96] We implicitly assume that all farms have the same number of animals, so that the % applied to the number of farms may also be applied to the number of animals.
[97] BPR 2005, Table C.2, for the province of Quebec.
[98] BPR 2005, Table C.2, for the province of Quebec.
[99] South Nation Authority (2003).
[100] We assume that animals are outside from May to October.
[101] CRAAQ, 2003 (for a dairy cow of 600 kg).

Quantity of phosphorus in manure – beef cattle (kg P/day)[102]	(T)	0,075
Phosphorus controlled by this BMP – dairy cows (kg P)	(U) = M*O*P*R*S	1,169
Phosphorus controlled by this BMP – beef cattle (kg P)	(V) = N*O*P*T	163
Total phosphorus controlled by this BMP (kg P/year)	(X) = U + V	**1,332**

Milkhouse Wastewater

Target level of uptake	(A)	85%
Current level of uptake (in 2003) [103]	(B)	49%
# of dairy cows[104]	(C)	16,438
# of dairy cows with milkhouse wastewater management - target	(D) = A * C	13,972
# of dairy cows with milkhouse wastewater management - current	(E) = B * C	8,055
# of dairy cows with milkhouse wastewater management – additional	(F) = D – E	5,918
Phosphorus controlled by this BMP[105] (kg P/animal)	(G)	0.69
Phosphorus controlled by this BMP[106] (kg P/year)	(H) = G*F	**4,083**

3 m wide Riparian Buffer Zones

Target level of uptake	(A)	85%
Current level of uptake (in 2003)[107]	(B)	51%
Buffer zone catchment (700m) (ha)[108]	(C)	28,478
Phosphorus controlled by this BMP (kg P/ha)[109]	(D)	0.56
Phosphorus controlled by this BMP (kg P/year)	(E) = (A-B)*C*D	**5,422**

Baseline concentration (0.041 mg/L)

Phosphorus loading between 2001 and 2003 (t/year)	(A)	49.1
Phosphorus controlled by forbidding livestock access to water (t/year)	(C)	1.3
Phosphorus controlled by milkhouse wastewater management (t/year)	(D)	4.1
Phosphorus controlled by 3 m wide riparian zones (t/year)	(E)	5.4
Phosphorus loading at 85% uptake of regulated BMPs (t/year)	(F) = A – (C+D+E)	38.2

[102] CRAAQ, 2003 (for a cow of 580 kg).
[103] BPR, 2005, Table A.2, for the Centre-du-Québec region.
[104] Computed from the 2006 Census of Agriculture data for municipalities that have more than 50% of their area inside the Nicolet sub-watershed.
[105] South Nation Authority (2003).
[106] South Nation Authority (2003).
[107] BPR 2005, Table A.11, for the Centre-du-Québec region.
[108] Because no scientific basis was found for the width of the buffer zone catchment of a riparian zone, the 700 m width was chosen based on a discussion with a researcher familiar with the Nicolet watershed, who found this number reasonable. The buffer zone catchment area was obtained via GIS data computed by Del Degan Massé, a subcontractor.
[109] South Nation Authority (2003).

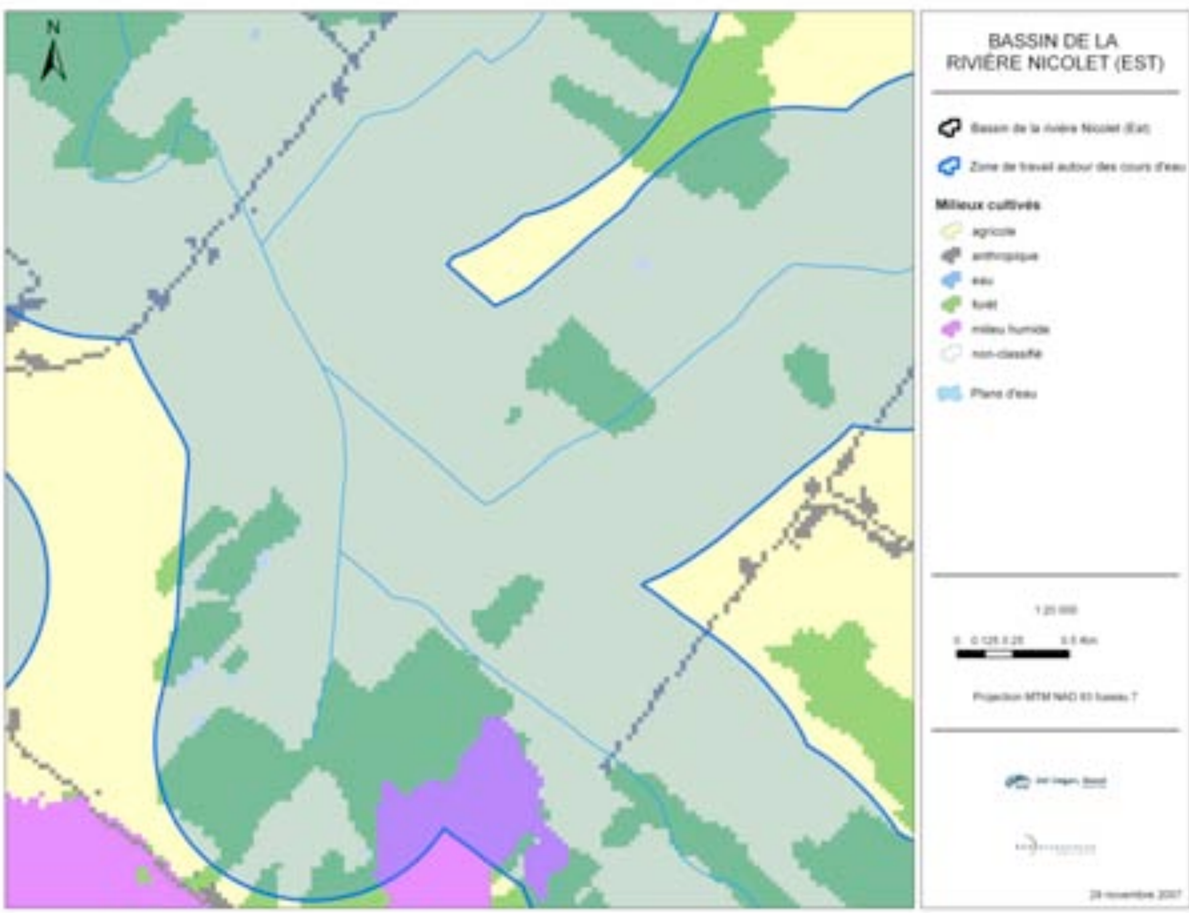
Flow (hm^3/year)	(G)	937
Phosphorus concentration at 85% uptake of regulated BMPs (mg/L)	(H) = F/G	**0.041**

Appendix 7

Buffer Zone Catchment Area for Riparian Zones

Figure 15 shows a part of the buffer zone catchment area of 1,400 m width (2*700 m). This buffer zone was determined in order to compute the area of cultivated land that potentially sends its phosphorus on the riparian zones. An implicit assumption is that riparian zones are implemented on both sides of the river, even in the case of wooded riparian zones. This could interfere with the river-cleaning operations that are conducted every 15 to 25 years by municipalities, but we assume that because of the stabilization of shores, sedimentation is slowed down, increasing this period to 30 to 40 years, which can very well coincide with the time when leafy trees are cut.

FIGURE 15 : BUFFER ZONE CATCHMENT AREA OF 700 M WIDTH ON EACH SIDE OF THE RIVER



Appendix 8

Description of the BMPs Chosen for this Study in Both Watersheds

Manure Storage

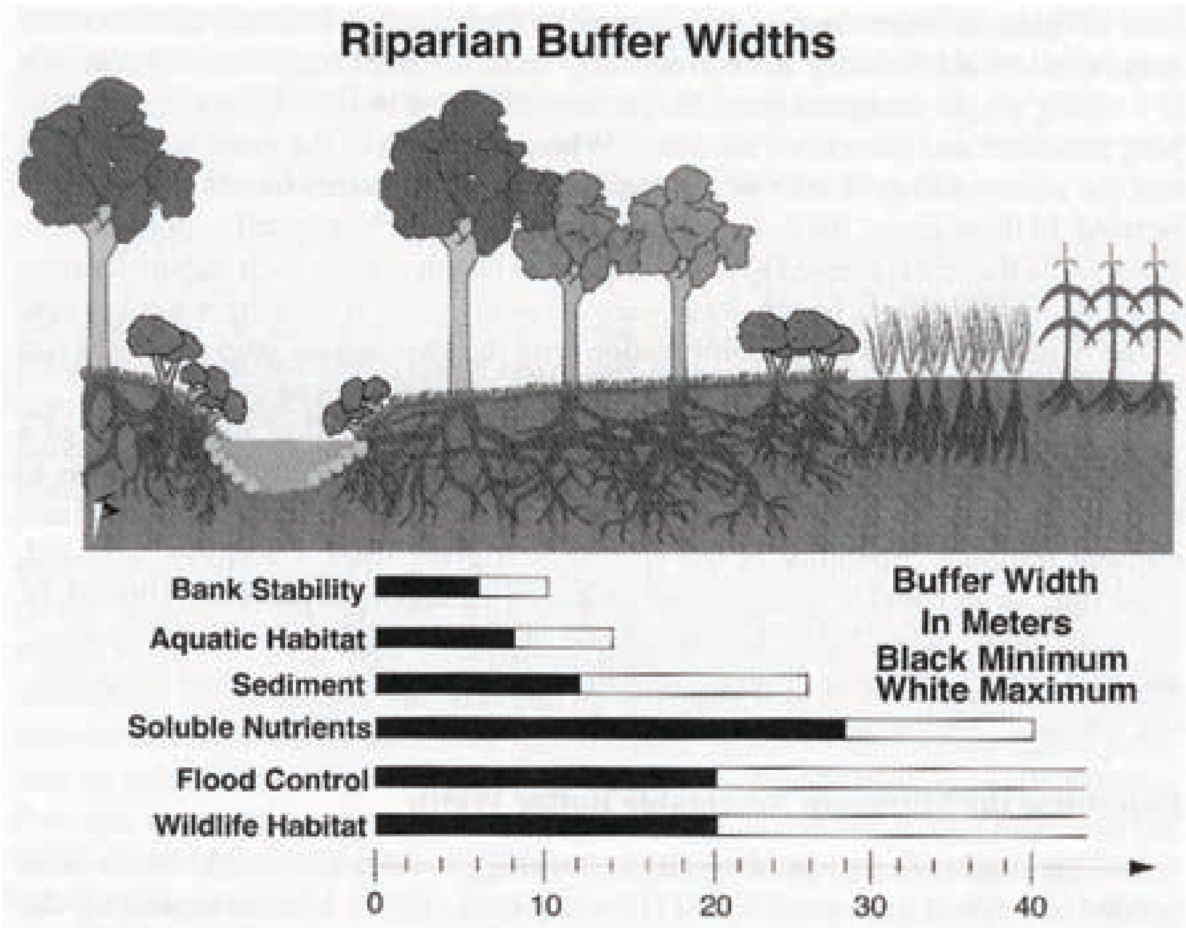
Though different storage modes (solid, semi-solid or liquid) affect the amounts of plant nutrients preserved in manure management, this beneficial management practice is heavily influenced by the spreading method and its timing and soil incorporation time. An ideal storage system should prevent nutrient loss during storage and provide enough capacity until the field is safely covered. Spreading should be done in a way that reduces nutrient runoff into ground- and surface water. Farmers have to keep a number of factors in mind when choosing the most suitable facility. These factors include cost, efficiency, manure water-content, facilities' capability to meet current and future needs and storage location relative to waterways, wells, neighbours' houses, etc. The facility choice should also be guided by local regulations.

Riparian Buffer Zones

As already pointed out, riparian buffer zones play an important role, not only in protecting water and habitat quality, but also in regularizing water flows and stabilizing banks. The term "zone" can denote various arrangements bordering bodies of water, such as areas exclusively composed of forage species or more varied vegetation with forage, bushes and trees. As a rule, species have to be suitable, hardy and non-invasive. In some cases, species sown in riparian zones may represent a source of income for the farmers.

Riparian zone design depends on site condition, soil type, gradient and runoff volume. Width depends on its impact on the various EG&S, as shown in Figure 16. Since provincially determined standards and technical requirements should guarantee the effectiveness of the zone, minimum required width can vary substantially by jurisdiction.

FIGURE 16 : RIPARIAN ZONE EFFECTIVENESS BY WIDTH (METRES)



Source: SCHULTZ et al. (2000).

Conservation Tillage (Reduced Till and No-till)

Conservation tillage is a beneficial management practice that leaves at least 30% of the soil surface covered by residues (stems, leaves, straw from the previous harvest) after seeding. This practice is divided into two major stages:

1. a primary stage in which the soil is broken up or lifted instead of turned over, and
2. a secondary stage in which we prepare the seed bed, level the soil surface (one or two passes with an implement) and incorporate fertilizers and herbicides.

As a rule, the primary stage is conducted in fall and the secondary stage in spring. Some 30% to 40% of crop residues are incorporated into soil where corn or grain was grown. The main tool used at the primary stage is a chisel plough to aerate the soil. Thereafter, the offset disc plough is used to further shred incorporated residues and apply needed fertilizers and herbicides. This system is seen as less intensive than conventional tillage, which incorporates a higher percentage of crop residues with a mouldboard plough.

This practice helps water quality in a number of ways, for example by limiting water and wind erosion through better coverage and increased organic matter in the soil. Conservation tillage has various non-environmental advantages such as time savings in soil preparation. However, we must realize that the success of this BMP depends on effective control of crops, weeds and residues. For this reason, its best performance requires the simultaneous use of other practices (CPVQ, 2000).

Cover Crops

Generally speaking, cover crops are put in to offer protection in periods when commercial crops cannot be grown. These cover plants help to limit erosion and runoff. They reduce the amount of soil and nutrients moving toward surface waters. This practice's other advantages include organic soil enrichment and improved soil structure. However, the use of cover crops often requires farmers to change their use of fields and farm implements, especially seeders.

Cover crops can be introduced in a number of ways. Winter covers are sown after harvest and remain in the field until the seed bed is prepared in the spring. The earlier these covers are established, the more effective the practice will be. In mild regions (the Prairies and Western Canada), winter cover growth simply slows in cold weather while continuing to slow water and nutrient runoff. In colder regions (Eastern Canada), crops have to be established as early as possible for maximum nutrient absorption before the plant dies or falls dormant.

Another way of introducing this practice is to plant relay crops that are actually a kind of winter cover sown while the prior commercial crop is still growing. Row cropping systems are particularly suited to this kind of cover crop. In fact, relay crops make it possible to establish winter cover crops in fields used for annual crops, like corn and soya, that are harvested too late to plant a winter cover by the first method.

Annual fallow legumes for producing forage also function as cover crops and protect against erosion and runoff. Finally, cover crops also result from combining a green fertilizer crop (biennial legumes) with an annual commercial crop. After the first year, the annual commercial crop is harvested while the biennial crop keeps growing. The latter provides soil cover in fall until it performs its green fertilizer function through incorporation into the soil, usually in the spring.

Converting Marginal Farmland to Wetlands

This practice involves transforming less productive agricultural land to wetlands so they can serve as habitats for various wildlife species while at the same time decreasing the level of phosphorus that leaches into rivers.

Conservation of Existing Wetlands and Forests in Agricultural Zones

Mainly because they are so fertile, various wetlands and woodlands are cleared and planted every year. Generally speaking, the beneficial management practice would involve preserving wetlands and forests in farming areas, since these environments are all crucial for wildlife.

This type of intervention is new to agricultural environmental protection. Manitoba's Alternate Land Use Services (ALUS) pilot project is certainly the most developed program of this kind in Canada at this time. On a case by case basis, it offers farmers compensation by the hectare for preserving a range of natural environments in agricultural districts. For wetlands, the level of compensation varies to reflect use, for example, if no agriculture is practised, if forage is harvested, or if livestock are pastured there. The BMP we used for our analysis is based on the first of these options: the conservation of wetlands and woodlands to leave them in the wild state.

Removing Lands Prone to Flooding from Production

This practice involves restoring agricultural floodplains to their natural state so they can serve as habitats for various wildlife species. Like the conservation of wetlands and woodlands, the future generalization of this practice will basically be limited to the existing areas in the watersheds.

Appendix 9

Parameters Chosen to Evaluate the Costs Associated to Buffer Strips

Buffer zones establishment	
Parameter	**Value**
Length of the hedge	1,000 m
Number of lines	3
Spacing between lines	3 m
Spacing between noble leafy trees	3 m
Spacing between willows	0.25 m
Rates	
Parameter	**Value**
Annual actualization rate	3 %
Interest rate for investments	3 %
Interest rate for credits	6 %
Annual inflation rate	2.75 %

Establishment costs	
Parameter	**Value**
Price of a plastic roller	175 $
Price of a "collerette"	0.15 $
Price of a "broche pour collerette"	0.10 $
Hourly salary for establishing and maintaining the hedge	15 $/ha
Travelling expenses	0.35 $/km
Hourly salary for tillage mechanical work	60 $/ha
Plans and estimates (outright)	$250
Cost of a 2-years hybrid willow plantlet	$0.40
Cost of a 2-years noble leafy tree	$2.50
% of establishment cost covered by the provincial government (Greencover Canada Program)	50 %
Transport cost of plant species are not included in the simulation	

Maintenance costs	
Parameter	**Value**
% of establishment cost envisaged for dead trees replacement during the first year	10 %
Hourly salary for pour le mowing and phytosanitary inspection	45 $/ha
Number of mowings per year	2
Travel expenses for the machinery	0.70 $/km
Price of a spiral of protection against rodents	$1
Price of a protection tube against deer (installation included)	$6

Income from the wood collected	
Parameter	**Value**
Value of noble leafy trees soled for sawing	118 $/m^3
Value of hybrid willows soled as biomass	85 $/tone of dry matter

Appendix 10

Effluent Trading Schemes

The theoretical model, however, is not always reflected in reality. If the target results are to be achieved, a number of market conditions need to be met. In practice, effluent trading schemes cannot operate effectively where trade in effluent permits is characterized by the following:

- A few players have major market power: they can manipulate prices and quantities to their advantage, thereby eliminating the possibility of achieving the optimal economic solution;
- Transaction costs are extremely high: it is no longer profitable to trade in permits, thereby preventing the effective distribution of permits and the achievement of the reduction objectives at the lowest cost;
- There is no appropriate monitoring of effluent or discharge: the effluent levels stipulated in the effluent permit allocation process are not complied with.

Several considerations need to be taken into account when implementing a permit trading scheme. First, nutrient effluent comes from several sources (agriculture, septic tanks, wastewater treatment plants and certain industries), all of which makes the effluent measurement and control process more complicated. Second, most water pollution sources are small, diffuse and very numerous. Over and above these constraints (even though some progress has been made with measurement and control in the form of scientific models for estimating effluent volumes), the inclusion of agriculture among the effluent sources complicates the search for solutions because direct environmental regulation remains virtually impossible to implement (Schary and Fisher-Vanden, 2004).

One of the major difficulties associated with effluent permit trading lies in the uncertainty of the effluent reductions associated with BMPs in agriculture. To address this uncertainty, instead of a 1:1 exchange (1 less kg of effluent allowing 1 more kg of discharge), most programs use ratios of 2:1 or higher (2 kg less effluent allowing 1 kg of discharge). Another important benefit of such exchange ratios is the greater likelihood of achieving the overall effluent reduction objective. In most existing programs, these ratios are determined scientifically.

Most current experience is based on trading between point sources and non-point sources. Agricultural operations are usually the most common form of non-point sources that are not directly regulated. For these non-point sources, the trading system is generally used in conjunction with other voluntary programs to reduce the impact of specific pollutants. While the most common pollutants targeted are phosphorus and nitrogen, a few programs target sediment and a number of other specific pollution factors – selenium, biological oxygen demand (BOD), etc.

Despite the difficulties associated with implementing such programs, their value is constantly growing because of several highly attractive characteristics:

a) This type of instrument is specific and can be adapted to individual situations – it is a decentralized system;
b) The approach is based on innovative procedures;
c) The participation of farmers and their local associations is a fundamental component – these are voluntary systems.

All things considered, the establishment of such systems is justified because of the major environmental challenges society is facing. In fact, this can be achieved where a formal target has been articulated for a particular watershed, and receptivity combined with government will exists at the national level to provide legal, institutional and financial support to such initiatives (pilot projects, etc.).

Two different types of effluent rights trading can be implemented by governments: permits and credits. The permit system is known as "cap and trade," while the credit system is generally called "baseline and credit."

The "Cap and Trade" Permit System

This trading system is based on the government's establishment of an absolute upper limit for all sources covered by the program. This limit is based on the target environmental objective. Permission to emit or discharge is then given to the participating sources, with the maximum value of the total number of permits corresponding to this upper limit. These permits can then be traded among participants. Permit trading allows each source to adopt a strategy specific to its particular circumstances and based on the relative costs of the basic option of either introducing practices or technologies to reduce effluent or purchasing permits from another program participant. As a result, the participants with the lowest effluent reduction costs ensure achievement of the target level. Such programs are thus more effective and reduce the total cost of achieving a defined environmental objective. Since the level of pollution is set by an absolute threshold (cap), this is also called a "closed" system.

The "Baseline and Credit" System

This credit trading system is based on allocating a baseline level to each source. If a source lowers its emissions below its baseline, it can sell the surplus reduction as "credits" to sources that are exceeding their baseline limit. Thus, the trade that takes place is in reduction credits rather than in emission rights. Credits are only acquired when an enterprise reduces its pollution to a level lower than its baseline. This system is commonly called "baseline and credit."

Reductions aimed at achieving the baseline level cannot be transformed into credits. To ensure compliance with this requirement as well as the actual character of reductions, credits must be certified by recognized third-party institutions. This certification is a major component of the high transaction costs associated with most existing water quality programs.

Combining "Cap and Trade" and "Baseline and Credit" in an "Open" System

A combination of both systems is increasingly being used in situations where the "cap and trade" system is not able to cover most of the sources contributing to a given environmental problem and where the sources covered by the "cap and trade" system are facing high pollution reduction costs. Combining both systems implies that certain sources are regulated and that some permits are allocated, with the regulated enterprises able to trade permits among themselves as in the case of the "baseline and credit" system. In the case of an "open" system combining both methods, however, regulated enterprises can also purchase credits from non-regulated enterprises that voluntarily reduce their emissions below their baseline, as in the "baseline and credit" system.

Appendix 11

Opportunity Costs Associated with the Current Use of Land in the Nicolet sub-Watershed

Crop type	Cultivated area (ha)	% of total cultivated area	Land lease price ($/ha/year)	Opportunity cost associated with each culture ($/ha/year)
Hay and other forage crops	16,818.0	41.8 %	120	50.2
Grain corn	12,027.0	29.9%	240	71.8
Oats	3,740.0	9.3%	120	11.2
Silage corn	3,345.0	8.3%	120	10.0
Soya	2,745.0	6.8%	240	16.4
Barley	1,539.0	3.8%	120	4.6
Opportunity cost ($/ha)				**164.1**

Source: ÉcoRessources Consultants with other data from Beauregard and Brunelle (2007) and Statistics Canada (2007).

Appendix 12

Major Crops in the Little Saskatchewan River Watershed

Crop	Area (ha)	Percentage of Total Cropland
Total Cropland	180,008	
Wheat	54,689	30.4%
Canola	40,807	22.7%
Alfalfa and alfalfa mixtures	28,544	15.9%
Hay and field crops	17,092	9.5%
Oats	12,817	7.1%
Flaxseed	9,184	5.1%
Other tame hay and fodder crops	8,230	4.6%
Dry field peas	2,800	1.6%
Total rye	1,220	0.7%
Forage seed harvested as seed	1,199	0.7%
Sunflowers	1,013	0.6%
Mixed grains	794	0.4%
Total corn	604	0.3%
Mustard seed	329	0.2%
Other Crops	686	0.4%

Source: Statistics Canada (2007).

Appendix 13

Private Costs of Establishing a Wooded Riparian Buffer Zone in the Two Watersheds

TABLE 80 : PRIVATE COSTS OF ESTABLISHING A RIPARIAN BUFFER ZONE ON A HECTARE OF CULTIVABLE LAND ($/HA)

Year	Establishment cost of wooded buffer zones	Cost of losing cultivable land	Maintenance cost of wooded buffer	Revenue from wood	Total cost minus revenue from wood
1	2,142	164	671	0	2,977
2	-	164	670	0	834
3	-	164	668	98	734
4	-	164	666	98	732
5	-	164	665	97	732
6	-	164	394	97	461
7	-	164	393	97	460
8	-	164	392	97	459
9	-	164	391	96	459
Total	2,142	1,476	4,910	680	7,848

TABLE 81 : PROJECTED PRIVATE COSTS FOR ESTABLISHMENT OF WOODED RIPARIAN BUFFER ZONES IN THE LITTLE SASKATCHEWAN RIVER WATERSHED ($/HA)

Year	Yearly annual margin	Cumulative margin	Implementation costs	Opportunity cost	Maintenance costs	Revenue	Total costs
1	$2,932.80	$2,932.80	$2,142.00	61.78	$671	0	2,875
2	$786.31	$3,719.11		59.98	$670	0	730
3	$679.63	$4,398.74		56.54	$668	$98	627
4	$668.33	$5,067.08		51.74	$666	$98	620
5	$657.14	$5,724.22		45.97	$665	$97	614
6	$373.90	$6,098.11		39.65	$394	$97	337
7	$360.40	$6,458.51		33.21	$393	$97	329
8	$347.36	$6,805.87		27.00	$392	$97	322
9	$336.33	$7,142.21		21.32	$391	$96	316
Total							6,769

Appendix 14

Private Costs of Establishing a Grassy Riparian Buffer Zone in the Nicolet Sub-Watershed

Seeds	**Qty/km of watercourse**			**Unit price ($)**			**Total**		
	1 m wide	**3 m wide**	**10 m wide***				**1 m wide**	**3 m wide**	**10 m wide***
Red fescue (kg)	2.4	7.2	24	$3.53			$8.47	$25.42	$84.72
White clover (kg)	0.6	1.8	6	$10.00			$6.00	$18.00	$60.00
Bluegrass (kg)	0.6	1.8	6	$4.25			$2.55	$7.65	$25.50
Total							$17.02	$51.07	$170.22
Tillage operations				**Unit price ($)**			**Total**		
Broadcast seeding	1			$13.00			$13.00		
Ploughing (loam)		1	1		$18.94			$18.94	$63.13
Heavy harrowing (disk)		1	1		$3.56			$3.56	$11.87
Light harrowing (vibrator tiller)		1	1		$2.88			$2.88	$9.60
Seed drill seeding		1	1		$6.05			$6.05	$20.17
Total							$13.00	$31.43	$104.77
Total establishment cost per km of watercourse							$32.04	$88.56	$295.19
				Total establishment cost per hectare **					$295.19
Maintenance	**No. of passes/km of watercourse**			**Unit price ($)**			**Total**		
	1 m wide	**3 m wide**	**10 m wide***	**1 m wide**	**3 m wide**	**10 m wide***	**1 m wide**	**3 m wide**	**10 m wide***
Reseeding if necessary	0	0	0	$13.00	$6.05	-	$ -	$ -	$ -
Maintenance (grass cutting if necessary)	1	1	1	$1.04	$3.12	$10.40	$1.04	$3.12	$10.40
Total maintenance cost per km of watercourse							$1.04	$3.12	$10.40
				Total maintenance cost per hectare **					$10.40

*The results for a typical riparian buffer zone 10 m wide are based on an extrapolation from the 1 m – and 3 m models. Source: CRAAQ (2007).

**For a 10-m model on a kilometre of watercourse, the establishment cost was obtained by multiplying 10 m by 1,000m (1 km), which equals 10,0000m^2 or 1 hectare.

Appendix 15

Cost of Specialized Machinery for Reduced Till and no-Till in the Nicolet Sub-Watershed

Corn			
	Conventional	**Reduced till (chisel plough)**	**No-till**
6-moldboard plough	$25,500		
Chisel plough		$18,500	
Heavy harrower	$26,000	$26,000	
Vibrator tiller	$21,500	$21,500	
Seed drill	$45,000	$45,000	$49,600
Total	**$118,000**	**$111,000**	**$49,600**
Soya			
6-moldboard plough	$25,500		
Chisel plough		$18,500	
Heavy harrower	$26,000	$26,000	
Vibrator tiller	$21,500	$21,500	
Seed drill	$21,000	$21,000	$50,000
Total	**$94,000**	**$87,000**	**$50,000**

Source: CDAQ – MAPAQ (2005).

Appendix 16

Economic Benefit through Different BMPs - Nicolet Sub-Watershed

Simulated impacts of alternative practices on farm net returns over the 30-year time horizon

Scenario	Dairies		Swine		Beef			Mixed farms	Watershed aggregate
	Tie stall	Free stall	Open lot	Large confined	Fed cattle	Beef cow/calf	Calf and heifer		
Baseline: $ per farm	69321	152493	−10581	196701	−18604	−19316	−12323	71261	42467
Baseline: $ per hectare	342.3	473.3	−43.1	450.9	−64.6	−102.9	−104.2	530.3	186.5
Changes from baseline: $ per hectare									
1. No till	−7.5	−4.7	−10.5	−12.8	−13.7	−13.7	−12.2	−13.5	−10.3
2. Incorporation	−2.1	−3.3	−1.7	0.0	−1.9	−0.5	−0.7	−3.6	−1.8
3. Injection	0.0	0.0	0.0	−8.4	0.0	0.0	0.0	0.0	−0.7
4. Terraces	−64.1	−64.6	−56.3	−60.3	−65.8	−76.5	−66.5	−70.7	−64.8
5. Contouring	−7.4	−7.9	−3.6	−7.7	−6.4	−5.8	−4.2	−5.0	−6.4
6. In-field contour buffers	−38.5	−28.8	−29.7	−25.4	−7.9	−8.9	−23.2	−38.5	−26.0
7. Grassed waterways	−23.9	−26.8	−19.1	−23.4	−17.7	−17.7	−22.5	−26.0	−21.7
8. No till and reduced fertilizer	36.1	41.0	48.7	46.8	45.8	45.6	40.3	37.2	42.2
9. Contour buffers and reduced fertilizer	−2.1	9.7	19.9	24.9	42.2	40.6	20.7	3.7	18.0
10. Contours and reduced fertilizer	36.7	39.1	56.3	53.7	54.0	54.1	48.7	46.1	46.9
11. No till and injection	−9.3	−8.4	−4.7	−8.4	−6.6	−4.3	−5.3	−13.0	−7.6

These simulations are applicable to farm models in Iowa, USA.

Source: Gassman et al. (2006).

Appendix 17

Private Cost of Planting an Annual Cover Crop - Nicolet Sub-Watershed

	2004	2005	2006	2007	Average
Timothy/alfalfa: pure seeding	$157	NA	$150	$149	**$152**
Timothy/alfalfa: alfalfa established with barley as a companion crop	$153	NA	$151	$149	**$151**
Timothy/alfalfa without a companion crop for commercial hay (marketed in big rectangular bales)	$157	NA	$151	$150	**$153**
Variable costs of planting a timothy/alfalfa mix as a cover crop on a hectare of land					**$152**

Source: ÉcoRessources Consultants with data from Beauregard and Brunelle (2004 – 2007).

Appendix 18

Unitary One-Time Payments for the Two Watersheds

TABLE 82 : ONE-TIME PAYMENT FOR ONE HECTARE OF GRASSY RIPARIAN BUFFER ZONE (WITHOUT MAINTENANCE) IN THE NICOLET SUB-WATERSHED

Year	Incentive to establish grassy riparian buffer zones (50%)	Actualized cost of losing cultivable land	Total one-time payment per ha (grant for investment + total actualized opportunity cost)
1	148	175	**1,547**
2	-	169	
3	-	164	
4	-	160	
5	-	155	
6	-	151	
7	-	146	
8	-	142	
9	-	138	
	Total	1,399	

TABLE 83 : ONE-TIME PAYMENT FOR 1 HA OF RIPARIAN BUFFER ZONE

Year	Grant to establish grassy riparian buffer zones (50%)	Actualized cost of losing cultivable land	Total one-time payment per ha (grant for investment + total actualized opportunity cost)
1	148	61.77	**545**
2	-	60	
3	-	57	
4	-	52	
5	-	46	
6	-	40	
7	-	33	
8	-	27	
9	-	21	
	Total	397	

TABLE 84 : ONE-TIME PAYMENT FOR A FARM THAT ADOPTS NO-TILL IN THE NICOLET SUB-WATERSHED

Year	Cost of specialized equipment for no-till	Grant to purchase specialized no-till equipment (30%)	Technical assistance from an agronomist for 2 years	One-time payment
1	$50,000	$15,000	$550	**$15,550**
2			$550	**$550**

TABLE 85 : ONE-TIME PAYMENT FOR A FARM THAT ADOPTS REDUCED TILLAGE IN THE NICOLET SUB-WATERSHED

Year	Cost of specialized equipment for reduced tillage	Grant to purchase of specialized reduced tillage (30%), max. $15,000	Technical assistance from an agronomist for 2 years	One-time payment
1	$98,500	$15,000	$550	**$15,550**
2			$550	**$550**

Appendix 19

Unitary Annual Payments for the Two Watersheds

TABLE 86 : ANNUAL PAYMENT FOR ONE HECTARE OF WOODED RIPARIAN BUFFER ZONE WITHIN THE NICOLET SUB-WATERSHED

Year	Grant to establish wooded riparian buffer zones (50%)	Annual payment (loss of cultivable land, maintenance, less lumber income) ($)	Total annual payment ($)
1	1,071	846	1,917
2	-	845	845
3	-	745	745
4	-	743	743
5	-	743	743
6	-	472	472
7	-	471	471
8	-	470	470
9	-	470	470
Total over 9 years for 1 ha			**6,872**

TABLE 87 : ANNUAL PAYMENT FOR ONE HECTARE OF WOODED RIPARIAN BUFFER ZONE WITHIN THE LITTLE SASKATCHEWAN RIVER WATERSHED

Year	Grant to establish wooded riparian buffer zones (50%)	Annual payment (loss of cultivable land, maintenance, less lumber income) ($)	Total annual payment ($)
1	1,071	1,803.77	2,874.77
2	-	729.97	729.97
3	-	626.53	626.53
4	-	619.73	619.73
5	-	613.96	613.96
6	-	336.65	336.65
7	-	329.20	329.20
8	-	322.00	322.00
9	-	316.31	316.31
Total over 9 years for 1 ha			**6,769**

TABLE 88 : ANNUAL PAYMENT FOR FARMS USING INTERCROPPING (FOR NICOLET EAST WATERSHED ONLY)

Year	Cost of seed and ploughing (51 ha * 152 $/ha)	Technical assistance ($)	Annual payment (cost of seed and ploughing + technical assistance) ($)
1	7,779	550	1,329
2	7,779	550	1,329
3	7,779	-	7,779
4	7,779	-	7,779
5	7,779	-	7,779
6	7,779	-	7,779
7	7,779	-	7,779
8	7,779	-	7,779
9	7,779	-	7,779
Per farm ($/farm) (A)			**71,112**

For 1 hectare ($/ha)	(B) = A/51ha	**1,394**

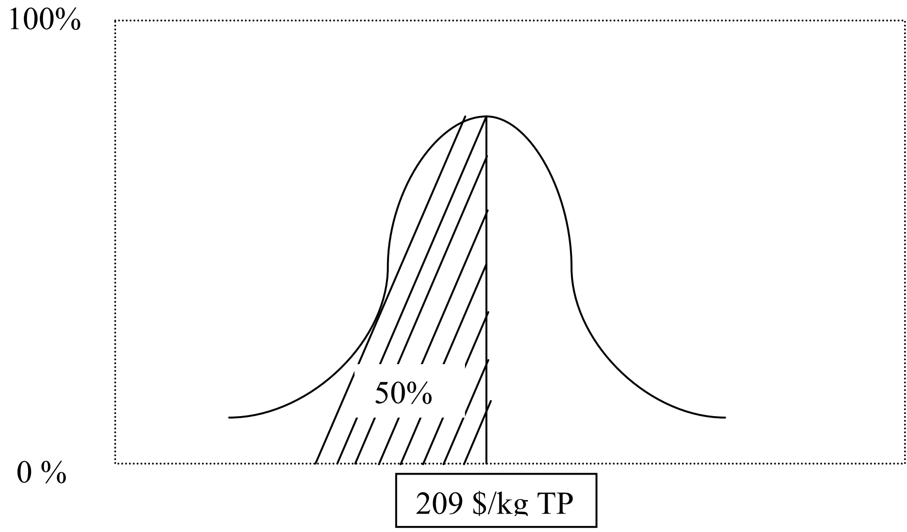
TABLE 89 : ANNUAL PAYMENT FOR ONE HECTARE OF COVER CROPS FOR CEREALS IN THE NICOLET SUB-WATERSHED

Year	Cost of ploughing (21,25 ha * $4/ha)	Technical assistance ($)	Annual payment (cost of ploughing + technical assistance) ($)
1	85	550	635
2	85	-	85
3	85	-	85
4	85	-	85
5	85	-	85
6	85	-	85
7	85	-	85
8	85	-	85
9	85	-	85
Per farm ($/farm)	(A)		**1,315**
For 1 hectare ($/ha)	(B) = A/21ha		**62**

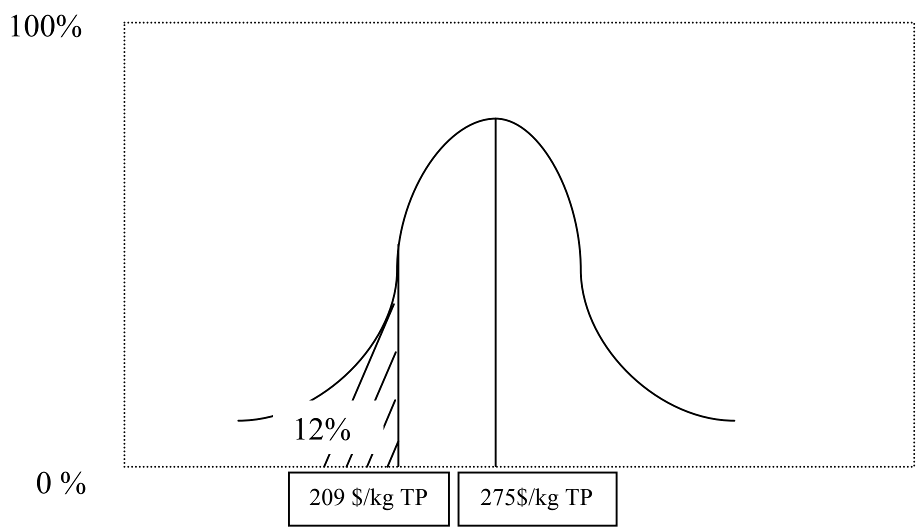
Appendix 20

Auctions and Tradable Permits: Graphic Explanation of the Distribution of Private Costs of BMPs on the Nicolet Sub-Watershed (Normal Distribution)

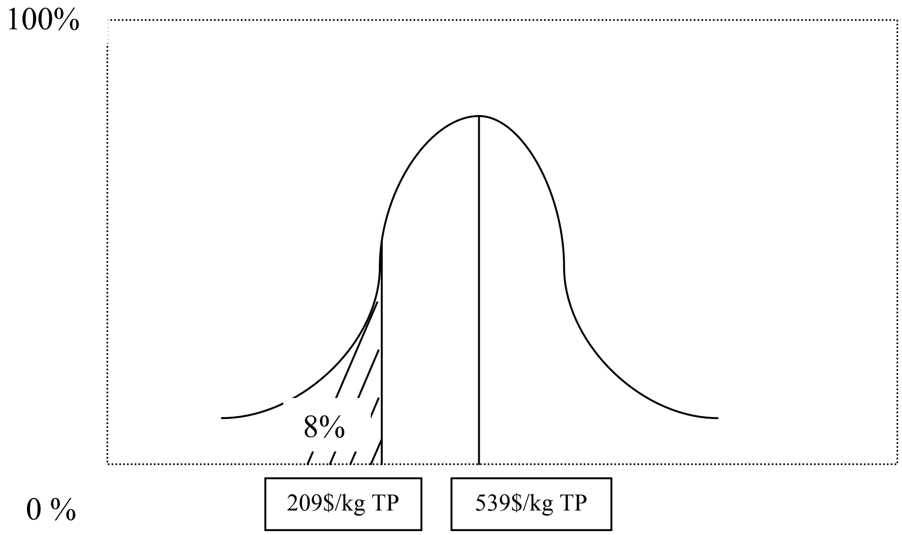
<u>BMP: Winter cover crops for cereals (the most efficient BMP)</u>



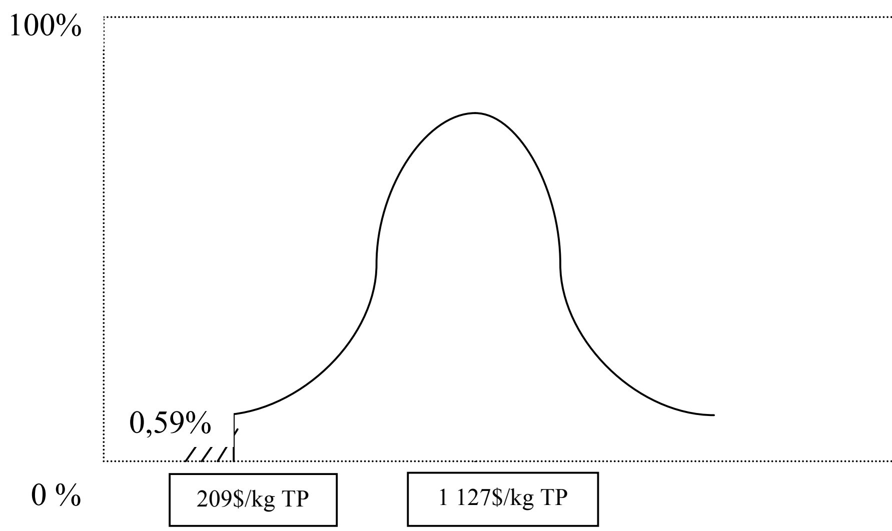
<u>BMP: Grassed riparian buffers</u>



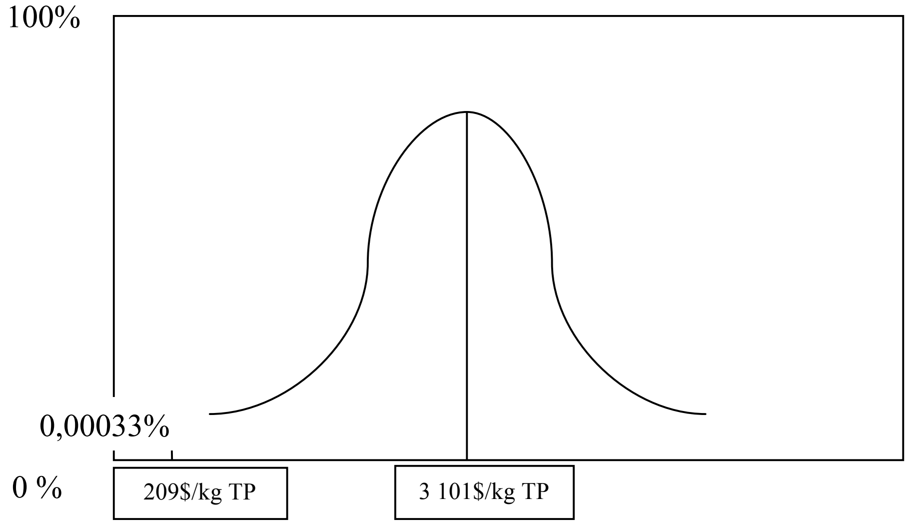
<u>BMP: Reduced tillage and no-till</u>



<u>BMP: Wooded riparian buffers</u>



BMP: Intercropping



Appendix 21

Total Costs of Policies in the Nicolet and Little Saskatchewan River Watersheds

	One-time payments (million $)		**Annual payments** (million $)		**Mixed one-time/annual payments** (million $)		**Auctions** (million $)		**Tradable permits** (for P only) (million $)	
	N(E)W	LSRW	N(E)W	LSRW	N(E)W	LSRW	N(E)W	LSRW	N(E)W	LSRW
Total water costs	1.49	2.82	5.23	7.46	1.51	0.68	0.78	0.82	0.62	0.75
Total habitat costs	0.67	0.23	0.60	0.29	0.60	0.32	0.40	0.32	-	0.29
Total costs	**2.17**	**2.82**	**5.83**	**7.46**	**2.11**	**0.68**	**1.19**	**0.82**	**0.62**	**0.75**

N (E) W: Nicolet sub-watershed
LSRW: Little Saskatchewan River watershed

Note that in Little Saskatchewan River watershed, BMPs aiming at reducing phosphorus concentrations in watercourses are also used to create habitat. Therefore, water costs in Little Saskatchewan River include both water and habitat costs.

Appendix 22

Estimated Gross Income per Household in 2003 in the Two Watersheds Studied

Nicolet

2003 income

Income per worker in the RCM[110] of Amiante[111]	(A)	C$28,625
Income per worker in the RCM of Arthabaska[112]	(B)	C$31,778
Income per worker in the RCM of Nicolet – Yamaska[113]	(C)	C$28,907
Income per worker in the three RCMs	(D) = (A+B+C)/3	C$29,770
Weekly income per worker in QC[114]	(E)	C$619
Annual income per household in QC	(F) = 52 * E	C$51,935
Annual worker income in QC[115]	(G)	C$32,201
Household/worker income ratio	(H) = F/G	1.613
Household income in the three RCMs in C$	(I) = H*D	C$48,014
US$/C$ exchange rate (2003 average)[116]	(J)	1.4015
Household income in the three RCMs in US$	**(K) = I/J**	**US$34,259**

[110] RCM = Regional County Municipality
[111] Internet site of Institut de la statistique du Québec 2008: http://www.stat.gouv.qc.ca/regions/profils/profil12/societe/marche_trav/indicat/remun_age_mrc12.htm#Amiante
[112] Internet site of Institut de la statistique du Québec 2008: http://www.stat.gouv.qc.ca/regions/profils/profil17/societe/marche_trav/indicat/remun_age_mrc17.htm
[113] Internet site of Institut de la statistique du Québec 2008: http://www.stat.gouv.qc.ca/regions/profils/profil17/societe/marche_trav/indicat/remun_age_mrc17.htm
[114] Internet site of Institut de la statistique du Québec 2008: http://www.stat.gouv.qc.ca/donstat/societe/march_travl_remnr/remnr_condt_travl/008_rem_heb_emp_9706.htm
[115] Internet site of Institut de la statistique du Québec 2008: http://www.stat.gouv.qc.ca/donstat/societe/famls_mengs_niv_vie/revenus_depense/revenus/revfam96_2005.htm
[116] Internet site of the Bank of Canada 2008: http://www.bankofcanada.ca/fr/taux/exchange-avg-f.html.

2002 income

Income per worker in the RCM[117] of Amiante[118]	(A)	C$28,102
Income per worker in the RCM of Arthabaska[119]	(B)	C$31,258
Income per worker in the RCM of Nicolet – Yamaska[120]	(C)	C$28,010
Income per worker in the three RCMs	(D) = (A+B+C)/3	C$29,123
Weekly income per worker in QC[121]	(E)	C$606
Annual income per household in QC	(F) = 52 * E	C$50,932
Annual worker income in QC[122]	(G)	C$31,515
Household/worker income ratio	(H) = F/G	1.616
Household income in the three RCMs in C$	(I) = H*D	C$47,067
US$/C$ exchange rate (2003 average)[123]	(J)	1.5704
Household income in the three RCMs in US$	**(K) = I/J**	**US$29,971**

[117] RCM = Regional County Municipality.
[118] Institut de la statistique du Québec Web site 2008: http://www.stat.gouv.qc.ca/regions/profils/profil12/societe/marche_trav/indicat/remun_age_mrc12.htm#Amiante
[119] Institut de la statistique du Québec Web site 2008: http://www.stat.gouv.qc.ca/regions/profils/profil17/societe/marche_trav/indicat/remun_age_mrc17.htm
[120] Institut de la statistique du Québec Web site 2008: http://www.stat.gouv.qc.ca/regions/profils/profil17/societe/marche_trav/indicat/remun_age_mrc17.htm
[121] Institut de la statistique du Québec Web site 2008: http://www.stat.gouv.qc.ca/donstat/societe/march_travl_remnr/remnr_condt_travl/008_rem_heb_emp_9706.htm
[122] Institut de la statistique du Québec Web site 2008: http://www.stat.gouv.qc.ca/donstat/societe/famls_mengs_niv_vie/revenus_depense/revenus/revfam96_2005.htm
[123] Bank of Canada Web site 2008: http://www.bankofcanada.ca/fr/taux/exchange-avg-f.html.

Little Saskatchewan River

2006 income in 2003 US$

Income per household in the LSR watershed in 2005[124]	(A)	C$38,581
2003 consumer price index [125]	(B)	102.2
2006 consumer price index [126]	(C)	107.5
Income per household in the LSR watershed in 2003 C$	(D) = A*B/C	C$36,679
US$/C$ exchange rate (2003 average)[127]	(E)	1.4015
Income per household in the LSR watershed in 2003 US$	(F) = D/E	**US$26,171**

2006 income in 2002 US$

Income per household in the LSR watershed in 2005[128]	(A)	C$38,581
2002 consumer price index [129]	(B)	100.0
2006 consumer price index [130]	(C)	107.5
Income per household in the LSR watershed in 2002 C$	(D) = A*B/C	C$35,889
US$/C$ exchange rate (2002 average)[131]	(E)	1.5704
Income per household in the LSR watershed in 2002 US$	(F) = D/E	**US$22,853**

[124] The income per household for the Little Saskatchewan River watershed is estimated from the 2006 Census of Population data as weighted average of the median income per household specific to each municipality that has an important part of its area on this watershed.
[125] Statistics Canada 2008, Table 6, page 32.
[126] Statistics Canada 2008, Table 6, page 32.
[127] Internet site of the Bank of Canada 2008: http://www.bankofcanada.ca/fr/taux/exchange-avg-f.html.
[128] The income per household for the Little Saskatchewan River watershed is estimated from the 2006 Census of Population data as weighted average of the median income per household specific to each municipality that has an important part of its area on this watershed.
[129] Statistics Canada 2008, Table 6, page 32.
[130] Statistics Canada 2008, Table 6, page 32.
[131] Internet site of the Bank of Canada 2008: http://www.bankofcanada.ca/fr/taux/exchange-avg-f.html.

Appendix 23

Use of the Thomassin and Johnston 2008 Meta-Model to Estimate the WTP to Improve Surface Water Quality in the Two Watersheds Studied

	Model coefficients (A)	Nicolet		Little Saskatchewan River	
		Value of (B) variables	C = A * B	Value of (B') variables	C' = A * B'
Intercept	5.0010	1	5.0010	1	5.0010
Study design variables					
Study year	-0.0954	**32**	-3.0534	**32**	-3.0534
Contingent valuation	0.5308	0.4433	0.2353	0.4433	0.2353
Voluntary contributions	-1.2590	**0**	0	**0**	0
Interviews	1.0967	0.1546	0.1695	0.1546	0.1695
Via mail	0.4782	0.6288	0.3007	0.6288	0.3007
Lump sum	0.4096	**0**	0	**0**	0
Water quality scale	-0.1552	0.2680	-0.0416	0.2680	-0.0416
Protest votes	0.7519	0.3814	0.2868	0.3814	0.2868
Extreme prices (outlier bids)	-0.6459	0.1856	-0.1199	0.1856	-0.1199
High response rate	-0.6509	0.2577	-0.1677	0.2577	-0.1677
Policy-, resource- and context-related variables					
# of non-users	-0.5776	**0**	0	**0**	0
Income	0.000006	**29,971**	0.1765	**31,160**	0.1835
Multi-regions	0.6652	**0**	0	**0**	0
Canada	-1.5881	**1**	-1.5881	**1**	-1.5881
Single lake	0.3726	**0**	0	**0**	0
Estuary	0.3980	**0**	0	**0**	0
Saltwater ponds	0.6194	**0**	0	**0**	0
Freshwater	0.2326	**1**	0.2326	**1**	0.2326
Water quality change affecting non-specified species	0.2405	**2.5**	0.6013	**4,5**	1.0823
The study specifies a major increase in fish population or fishing rates	0.9619	**0**	0	**0**	0
Water quality reference level	-0.0532	**7**	-0.3727	**2,5**	-0.1331
		Column C total (D) =	1.6603		2.3879
		σ_e^2 error term variance (E) =	0.1572		0.1572
		WTP/household/year (US$ 2002) ($F = e^{D+E/2}$) =	$5.6909		$11.7806
		US$/C$ exchange rate (2002 average) (G)[132] =	1.5704		1.5704

[132] Bank of Canada Web site 2008: http://www.bankofcanada.ca/en/rates/exchange-avg.html.

WTP/household/year (C$ 2002) (H = F*G) =	$8.93	$18.50
Consumer Price Index in 2007 compared with 2002 (I)[133] =	109.80%	109.80%
WTP/household/year (C$ 2007) (J = H*I) **=**	**$9.81**	**$20.31**
Watershed population in 2003 (K)[134] =	53,266[135]	8,800[136]
Average number of members per household (Centre du Québec) 2006 (L)[137] =	2.4[138]	2.5[139]
Number of households in the watershed (M = K/L) =	22,194	3,520
WTP/watershed/year (C$ 2007) (N = J*M) =	$217,788	$71,503
Environmental benefit period (O) =	9 years	9 years
Actualisation rate (P) =	6%	6%
WTP/watershed, actualized over 9 years (C$ 2007) (N*(1/(1+P)^0+1/(1+P)^1+1/(1+P)^2+1/(1+P)^3+1/(1+P)^4+ 1/(1+P)^5+1/(1+P)^6+1/(1+P)^7+1/(1+P)^8)) =	**$1,570,203**	**$515,520**

133 Statistics Canada 2007b.
134 Ghazal et al. 2006 and our calculations.
135 Ghazal et al. 2006 and our calculations.
136 Little Saskatchewan River Conservation District and West Souris River Conservation District 2003.
137 ISQ (Institut de la Statistique du Québec) 2008: http://www.stat.gouv.qc.ca/regions/profils/profil17/societe/demographie/pers_demo/pers_men17.htm.
138 Institut de la Statistique du Québec Web site 2008: http://www.stat.gouv.qc.ca/regions/profils/profil17/societe/demographie/pers_demo/pers_men17.htm.
139 Statistics Canada Web site 2008: http://www12.statcan.ca/english/census06/data/profiles/community/Details/Page.cfm?Lang=F&Geo1=CSD&Code1=4615033&Geo2=PR&Code2=46&Data=Count&SearchText=Blanshard&SearchType=Begins&SearchPR=01&B1=All&Custom=

Appendix 24

Use of the Borrisova-Kidder 2006 Meta-Model (without Regional Variables) to Estimate the Benefit of Wetlands in the Two Watershed Studied

	Model coefficients (A)	Nicolet		Little Saskatchewan River	
		Value of variable (B)	C = A * B	Value of variable (B')	C' = A * B'
Intercept	-3.2220	1	-3.2220	1	-3.2220
Socio-economic variables					
Income	0.1380	**34**	4.7277	**35**	4,9244
Study year	0.1740	**16.32**	2.8397	**16.32**	2.8397
Wetland size					
Acres (in)	-0.0000004	**6.7332**	-0.0000028	**9.5176**	-0.0000040
Proportion of wetland in the region	-6.1290	**0.0272**	-0.1667	**0,064**	-0,3923
Wetland type					
Freshwater marsh	0.2070	**1**	0.2070	**1**	0.2070
Saltwater marsh	-2.3500	**0**	0.0000	**0**	0.0000
Prairie pothole	-2.5260	**0**	0.0000	**1**	-2.5260
Wetland functions					
Water supply	1.2920	**0**	0.0000	**0**	0.0000
Water quality	1.8770	**0**	0	**0**	0
Flooding	0.2770	**1**	0.2770	**1**	0.2770
Game fishing	0.6440	**0**	0.0000	**0**	0.0000
Commercial fishing	0.9260	**0**	0.0000	**0**	0.0000
Bird hunting	-0.3910	**1**	-0.3910	**1**	-0.3910
Bird watching	2.3440	**1**	2.3440	**1**	2.3440
Amenity	-2.0930	**1**	-2.0930	**1**	-2.0930
Habitat	-0.2150	**1**	-0.2150	**1**	-0.2150
Methodological variables					
Production function or market price method	-2.3610	0.07	-0.1653	0.07	-0.1653
Contingent valuation	-2.5020	0.39	-0.9758	0.39	-0.9758
Hedonic prices	2.1270	0.04	0.0851	0.04	0.0851
Travel cost method	-0.8290	0.06	-0.0497	0.06	-0.0497
Net factor income method	0.4720	0.19	0.0897	0.19	0.0897
Energy analysis method	5.1960	0.03	0.1559	0.03	0.1559
Newspaper article	1.7690	0.69	1.2206	0.69	1.2206
		Column C total (D) =	4.6682		2.1133
		σ_e^2 error term variance (E)[140] =	0.1572		0.1572
		Value/acre/year (US$ 2003) ($F = e^{D+E/2}$) =	$115		$9

[140] Since the Borisova-Kidder 2006 study does not provide any value for the error term variance, we are using the same value as that used in Thomassin and Johnston 2008.

US$/C$ exchange rate (2003 average) (G)[141] =	1.4015	1.4015
Value/acre/year (C$ 2003) (H = F*G) =	$161	$13
Consumer Price Index in 2007 compared with 2003 (I)[142] =	107.44%	107.44%
Value/acre/year (C$ 2007) (J = H*I) **=**	**$173**	**$13**
Number of acres for 1 ha (K) =	2.47	2.47
Value/hectare/year (C$ 2007) (L = J*K) **=**	**$428**	**$33**
Number of wetland ha evaluated (M) =	340	5,505
Value/watershed/year (C$ 2007) (N = M*L) =	$145,686	$18,311
Environmental benefit period (O) =	9 years	9 years
Actualization rate (P) =	**6%**	**6%**
Value/watershed, actualized over 9 years (C$ 2007) (N*(1/(1+P)^0+1/(1+P)^1+1/(1+P)^2+1/(1+P)^3+1/(1+P)^4+ 1/(1+P)^5+1/(1+P)^6+1/(1+P)^7+1/(1+P)^8)) =	**$1,050,563**	**$132,022**

141 Bank of Canada Web site 2008: http://www.bankofcanada.ca/en/rates/exchange-avg.html.
142 Statistics Canada 2007b.

Appendix 25

Use of the Borrisova-Kidder 2006 Model to Estimate the Benefit of Terrestrial Habitat (Woodland) in the Two Watersheds

	Model coefficients (A)	Nicolet		Little Saskatchewan River	
		Value of variable (B)	C = A * B	Value of variable (B')	C' = A * B'
Intercept	-10.3660	1	-10.3660	1	-10.3660
Study design variables					
Study year	0.4650	9.26	4.3059	9.26	4.3059
Acres (in)	0.3440	**7.62**	2.6211	**7.00**	2.4071
Newspaper article	-0.2720	0.83	-0.2258	0.83	-0.2258
Contingent valuation	1.5140	0.91	1.3777	0.91	1.3777
Terrestrial habitat functions					
Wildlife watching	6.6690	**1**	6.6690	**1**	6.6690
Open space	5.3310	**0**	0.0000	**0**	0.0000
Open space as habitat for several species	2.0140	**0**	0.0000	**0**	0.0000

	Nicolet	Little Saskatchewan River
Column C total (D) =	4.3820	4.2425
σ_e^2 error term variance (E)[143] =	0.0113	0.0113
Value/acre/year (US$ 2003) (F = $e^{D+E/2}$) =	$80	$70
US$/C$ exchange rate (2003 average) (G)[144] =	1.4015	1.4015
Value/acre/year (C$ 2003) (H = F*G) =	$113	$98
Consumer Price Index in 2007 compared with 2003 (I)[145] =	107.44%	107.44%
Value/acre/year (C$ 2007) (J = H*I) =	**$121**	**$105**
Number of acres for 1 ha (K) =	2.47	2.47
Value/hectare/year (C$ 2007) (L = J*K) =	**$299**	**$260**
Number of ha of terrestrial habitat evaluated (M) =	825	443
Value/watershed/year (C$ 2007) (N = L*M) =	$246,853	$143,143
Environmental benefit period (O) =	9 years	9 years
Actualization rate (P) =	**6%**	**6%**
Value/watershed, actualized over 9 years (2007 C$) (N*(1/(1+P)^0+1/(1+P)^1+1/(1+P)^2+1/(1+P)^3+1/(1+P)^4+ 1/(1+P)^5+1/(1+P)^6+1/(1+P)^7+1/(1+P)^8)) =	**$1,779,756**	**$1,032,033**

143 Since the Borisova-Kidder 2006 study does not provide any value for the error term variance, we are using the same value as that used in Thomassin and Johnston 2008.
144 Bank of Canada Web site 2008: http://www.bankofcanada.ca/en/rates/exchange-avg.html.
145 Statistics Canada 2007b.

Appendix 26

Resources for the Future Water Quality Ladder

	Scale benefits	Fecal coliforms # org/100 ml	Dissolved oxygen saturation **	Biological oxygen demand -5 Mg/L	Ph	Turbidity (JTU)
Weights*		.242	.274	.161	.194	.129
Drinking	9.5	0	90	0	7.25	5
Swimming	7	200	83	1.5	7.25	10
Game fishing	5	1000	64	3.0	7.25	50
Rough fishing	4.5	1000	51	3.0	7.25	50
Boating	2.5	2000	45	4.0	4.25	100

* The sum of the weights equals 1.
** Saturation percentage at 85°F.

Source: Vaughan (1986).

IQBP Water Quality Index

Summary description of water quality classes	Quality class	Fecal coliforms	Dissolved oxygen saturation	Biological oxygen demand: 5 mg/l	pH	Total Phosphorus (mg/l)
Good	A	< 200	88-124	< 1.7	6.9-8.6	< 0.03
Satisfactory	B	201-1,000	80-87	1.8 – 3.0	6.5-6.8	.031 - .050
Suspect	C	1,001 – 2,000	70-79	3.1 – 4.3	6.2-6.4	.051 - .10
Poor	D	2,001 – 3,500	55-69	4.4 – 5.9	5.8-6.1	.101 - .20
Very poor	E	>3,500	< 55	>5.9	<5.8	> 0.20

Source: Hébert (1996).

Appendix 27

Scaling-Up of the Total Payments for Each BMP

Central and Eastern Canada

One-time payments

Phosphorus	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (kg TP/ha) (B)	Potential area (C)		Target adoption rate (D)	Adoption rate before the incentive (E)	Total payment ($) A*B*C*(D-E)
Grassed riparian buffers	275	0.11	6,304,627	ha of cultivated area	60%	0%	114,428,981
Winter cover crops for cereals	209	0.4	2,192,620	ha of grains	40%	18%	40,326,661
No-till	539	0.5	6,905,736	ha of annual crops	35%	21%	269,858,899
Reduced till	539	0.35	6,905,736	ha of annual crops	35%	21%	188,901,229
				Total one-time payments for phosphorus =			**613,515,769**

Habitat	Payment per ha		# of ha	Total payment ($)
Woodland preservation	481	$/ha of woodland	510,293	245,450,698
Wetland preservation	722	$/ha of wetland	46,701	33,717,996
Removing lands prone to flooding from production	1,316	$/ha of lands prone to flooding	4,519	5,947,576
		Total one-time payments for habitat =		**285,116,270**

<u>Wetland</u> objective estimation for Central and Eastern Canada:

# of ha of wetland on the Nicolet =	(A)	4,672
# of ha of conserved wetland on the Nicolet =	(B)	340
% of conserved wetland on the Nicolet =	(C) = B/A	7.28%
% of conserved wetland in Central & Eastern Canada =	(D) = C	7.28%
# of ha of wetland in Central & Eastern Canada's agricultural watersheds[146] =	(E)	703,873
# of ha of conserved wetland in C&E Canada =	(F) = E*D	51,220
# of ha of preserved wetland on Nicolet=	(G)	310
# of ha of restored floodplains on Nicolet=	(H)	30
% of preserved wetland from total wetland objective on Nicolet=	(I) = G/(G+H)	91%
% of restored floodplains from total wetland objective on Nicolet=	(J) = H/(G+H)	9%
# of ha of preserved wetland in Central & Eastern Canada =	(K) = I*F	**46,701**
# of ha of restored floodplains in Central & Eastern Canada =	(L) = J*F	**4,610**

[146] Data provided by the Agri-Environmental Policy Bureau of Agriculture and Agri-Food Canada.

Woodland objective estimation for Central and Eastern Canada:

The following table shows the estimation of the woodland objective for New Brunswick. To obtain the aggregated sum at the level of the entire Central and Eastern Region the estimation is repeated for each province and the results are added. Also, to compute this objective for auctions, the procedure is the same except that we replace 825 ha by 1165 ha.

# of ha of woodland on the Nicolet =	59,771
# of ha of conserved woodland on the Nicolet =	825
% of conserved wetland on the Nicolet =	1.38%
% of conserved wetland in Quebec =	1.38%
# of ha of woodland in Quebec's agricultural areas =	7,331,086
# of ha of conserved woodland in Quebec =	101,188
Area of Quebec (km2) =	1,365,128
Area of this province (km2) =	71,450
% of this province's area with respect to the area of Quebec =	5.23%
# of ha of conserved woodland in this New Brunswick =	5,296
# of acres per ha =	2.47
# of acres of conserved woodland in New Brunswick =	**13,081**

Annual payments

Phosphorus	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (kg TP/ha) (B)	Potential area (C)		Target adoption rate (D)	Adoption rate before the incentive (E)	Total payment ($) A*B*C*(D-E)
Wooded riparian buffers	1,127	0.11	6,304,627	ha of cultivated area	80%	0%	625,267,693
Winter cover crops for cereals	209	0.4	2,192,620	ha of grains	80%	18%	113,647,862
Intercropping	3,101	0.35	1,432,473	ha of corn	20%	0%	310,946,914
						Total annual payments for phosphorus =	**1,049,862,470**

Habitat	Payment per ha		# of ha	Total payment ($)
Woodland preservation	540	$/ha of woodland	510,293	275,557,957
Wetland preservation	810	$/ha of wetland	46,701	37,827,668
Removing lands prone to flooding from production	1,477	$/ha of lands prone to flooding	4,519	6,675,205
			Total annual payments for habitat =	**320,060,830**

Mixed policy

Phosphorus	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (kg TP/ha) (B)	Potential area (C)		Target adoption rate (D)	Adoption rate before the incentive (E)	Total payment ($) A*B*C*(D-E)
Grassed riparian buffers	275	0.11	6,304,627	ha of cultivated area	60%	0%	114,428,981
Winter cover crops for cereals	209	0.4	2,192,620	Ha of grains	40%	18%	40,326,661
No-till	539	0.5	6,905,736	ha of annual crops	35%	21%	269,858,899
Reduced till	539	0.35	6,905,736	ha of annual crops	35%	21%	188,901,229
						Total mixed payments for phosphorus =	**613,515,769**

Habitat	Payment per ha		# of ha	Total payment ($)
Woodland preservation	481	$/ha of woodland	510,293	245,450,698
Wetland preservation	722	$/ha of wetland	46,701	33,717,996
Removing lands prone to flooding from production	1,316	$/ha of lands prone to flooding	4,519	5,947,576
			Total mixed payments for habitat =	**285,116,270**

Auctions

Phosphorus	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (kg TP/ha) (B)	Potential area (C)		Rate of adherence to the program (D)	Total payment ($) A*B*C*D
Grassed riparian buffers	275	0.11	6,304,627	ha of cultivated area	50%	95,357,484
Winter cover crops for cereals	275	0.4	2,192,620	ha of grains	94%	226,716,873
Reduced till	275	0.35	6,905,736	ha of annual crops	6%	39,880,625
No-till	275	0.5	6,905,736	ha of annual crops	6%	56,972,322
					Total payments for auction =	**418,927,305**

Habitat	Payment per ha		# of ha	Total payment ($)
Woodland preservation	481	$/ha of woodland	714,410	343,630,978
			Total payments for auction =	**343,630,978**

Tradable permits

Phosphorus	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (kg TP/ha) (B)	Potential area (C)		Rate of adherence to the program (D)	Total payment ($) A*B*C*D
Grassed riparian buffers	275	0.11	6,304,627	ha of cultivated area	50%	95,357,484
Winter cover crops for cereals	275	0.4	2,192,620	ha of grains	94%	226,716,873
Reduced till	275	0.35	6,905,736	ha of annual crops	6%	39,880,625
No-till	275	0.5	6,905,736	ha of annual crops	6%	56,972,322
					Total payments received by producers =	418,927,305
					% supported by the government =	75%
					% supported by the point sources =	25%
					Total payments for tradable permits supported by the government =	**314,195,478**

Western Canada

One-time payments

	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (B)		Potential area (C)		Target adoption rate (D)	Adoption rate before the incentive (E)	Total payment ($) A*B*C*(D-E)
Grassed riparian buffers (1)	19.17	0.67	kg TP/ha	4,264,990[147]	ha of cultivated area	80%	0%	43,823,285
Wetlands (2)	416.29	0.9	kg TP/ha	34,395,081	ha of cultivated area	3%	0%	386,594,863
Manure storage (3)	41.46	30	%	88,935,077	kg of P from animals	5%	0%	55,308,724
							Total one-time payments for phosphorus (1)+(2)+(3) =	**485,726,872**
							% of wetlands that counts as habitat objective[148] (4) =	10%
							Total one-time payments for habitat (2)*(4) =	**38,624,373**

[147] This represents the cultivated area within a 400 m catchment area. It is calculated by applying 12.4% to the total cultivated area (34,395,081 ha). The 12.4% are estimated from GIS data for Little Saskatchewan River and is considered representative for all Western Canada.

[148] The 10% represents the share of habitat objective for Little Saskatchewan River (550 ha) from the total are of wetlands recovered for phosphorus reduction (5505 ha).

The quantity of phosphorus eliminated by all cattle in Western Canada is estimated using data from the Census of Agriculture 2006 on the number of cattle by province:

	# of cattle[149]	P produced per animal[150] (kg/animal/day)	# of days of storage	Total P eliminated (kg of P)
AB	6,369,116			
BC	800,855			
MB	1,573,097	0,037	200	
SK	3,363,235			
Total	12,106,303			**88,935,077**

Annual payments

	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (kg TP/ha) (B)	Potential area (C)		Target adoption rate (D)	Adoption rate before the incentive (E)	Total payment ($) A*B*C*(D-E)
Wooded riparian buffers (1)	224.04	0.67	4,264,990[151]	ha of cultivated area	80%	0%	512,163,206
Wetlands (2)	519.28	0.9	34,395,081	ha of cultivated area	3%	0%	482,238,297,
Cover crops (3)	262.92	0.4	34,395,081	ha of cultivated area	5%	0%	180,863,094,
Total one-time payments for phosphorus (1)+(2)+(3) =							**1,175,264,597**
% of wetlands that counts as habitat objective[152] (4) =							10%
Total annual payments for habitat (2)*(4) =							**48,180,030**

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[149] Census of Agriculture 2006, Table 6.1-1.

[150] We use a mean value for all type of cattle, derived from
Table 25 by dividing the total quantity of phosphorus by the total number of cattle.

[151] This represents the cultivated area within a 400 m catchment area. It is calculated by applying 12.4% to the total cultivated area (34,395,081 ha). The 12.4% are estimated from GIS data for Little Saskatchewan River and is considered representative for all Western Canada.

[152] The 10% represents the share of habitat objective for Little Saskatchewan River (550 ha) from the total are of wetlands recovered for phosphorus reduction (5505 ha).

Mixed policy

	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (B)		Potential area or phosphorus in manure (C)		Target adoption rate (D)	Adoption rate before the incentive (E)	Total payment ($) A*B*C*(D-E)
Grassed riparian buffers (1)	19.17	0.67	kg TP/ha	4,264,990[153]	ha of cultivated area	100%	0%	54,779,106
Manure storage (2)	78.34	30	%	88,935,077	kg of P from animals	6.03%	0%	126,036,177
Total mixed payments for phosphorus (1)+(2) =								**180,815,282**
% of riparian buffers that count as habitat objective[154] (4) =								99%
Total mixed payments for habitat (1) =								**54,383,589**

Auctions

	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (B)		Potential area or phosphorus in manure (C)		Target adoption rate (D)	Adoption rate before the incentive (E)	Total payment ($) A*B*C*(D-E)
Grassed riparian buffers (1)	19.17	0.67	kg TP/ha	4,264,990[155]	ha of cultivated area	99.25%	0%	54,368,262
Manure storage (2)	41.46	30	%	88,935,077	kg of P from animals	5.90%	0%	65,264,295
Total payments for phosphorus (1)+(2) =								**119,632,557**
Total payments for habitat (1) =								**54,368,262**

[153] This represents the cultivated area within a 400 m catchment area. It is calculated by applying 12.4% to the total cultivated area (34,395,081 ha). The 12.4% are estimated from GIS data for Little Saskatchewan River and is considered representative for all Western Canada.

[154] The 10% represents the share of habitat objective for Little Saskatchewan River (550 ha) from the total are of wetlands recovered for phosphorus reduction (5505 ha).

[155] This represents the cultivated area within a 400 m catchment area. It is calculated by applying 12.4% to the total cultivated area (34,395,081 ha). The 12.4% are estimated from GIS data for Little Saskatchewan River and is considered representative for all Western Canada.

Tradable permits

	Payment per kg of phosphorus ($/kg TP) (A)	Phosphorus reduction potential (B)		Potential area or phosphorus in manure (C)		Target adoption rate (D)	Adoption rate before the incentive (E)	Total payment ($) A*B*C*(D-E)
Grassed riparian buffers (1)	19.17	0.67	kg TP/ha	4,264,990[156]	ha of cultivated area	99.25%	0%	54,368,262
Manure storage (2)	41.46	30	%	88,935,077	kg of P from animals	5.90%	0%	65,264,295
Total payments received by producers (phosphorus) =								119,632,557
% supported by the government =								90%
% supported by the point sources =								10%
Total payments for tradable permits supported by the government (phosphorus) =								**107,669,301**

Habitat co-benefit

Total payments received by producers (habitat) =	54,368,262
% supported by the government =	90%
% supported by the point sources =	10%
Total payments for tradable permits supported by the government (habitat) =	**48,931,436**

[156] This represents the cultivated area within a 400 m catchment area. It is calculated by applying 12.4% to the total cultivated area (34,395,081 ha). The 12.4% are estimated from GIS data for Little Saskatchewan River and is considered representative for all Western Canada.