

EG&S Cost-Efficiency Analysis

Environmental Goods and
Services technical meeting

Ottawa, April 30, 2009

Context and purpose of study

Short time frame (7 months)

Broad coverage (Across Canada)

Policies



BMP implementation (costs)



EG&S benefits

From cost-benefit to cost-efficiency of possible
EG&S policies or the reverse:

Comparing policies

Outline

- Policy options and design (5)
- Choice of representative watersheds (2)
- Choice of priority EG&S
- Current and target levels for priority EG&S
- Choice of Beneficial Management Practices (BMPs)
- BMPs adoption rates VS environmental targets
- Public costs of policy implementation
- Monetary values of environmental targets
- Comparison of the five policies (B/C)
- Extrapolation off benefits and costs

Policy options: What are we comparing?

Primary purpose: to encourage adoption of beneficial management practices (BMPs) to achieve target environmental goods and services (EGS)

- ⇒ One time payment:
- ⇒ Annual payments
- ⇒ Mixed policy: One time and annual payments
- ⇒ Auction system
- ⇒ Permit trading scheme

Policy design

Two representative watersheds West (Manitoba)+Central (Quebec)

- ✓ Selecting which portfolios of practices (BMP) that will qualify users for payments is a central part of the policy design process
- ✓ Reference level set for payments: Compliance with existing Provincial regulations
- ✓ Program delivery – Decentralized – Provincial jurisdiction –Manitoba and Quebec
- ✓ Oversight and control : Same for the two regions

One time payment

| 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 wide Cover crops Conservation tillage (no-till and reduced till) Conservation of wetlands in agricultural areas Crop reduction in agricultural floodplains. | Grassy buffer strips 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). | |

Auction-based Policy

“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.” McAfee and McMillan

- Two types or problems:
 - Absence of information on BMPs impact on environmental outcomes
 - ❖ Construction of an Environmental Benefit Indicator (EBI)
 - Asymmetric information (government-farmer) on costs of implementing BMPs
 - ❖ Auction = information revelation mechanism
- Format inspired from the Conservation Reserve Program in the United States (EBI) and the BushTender and EcoTender programs in Australia.

Tradable permit Policy

“Trading programs allow facilities facing higher pollution control costs to meet their regulatory obligations by purchasing environmentally equivalent (or superior) pollution reductions from another source at lower cost, thus achieving the same water quality improvement at lower overall cost.” US EPA






























- Based on the South-Nation pilot project in Ontario and experiences in the US and Australia
- Watershed based system
- Needs a clearly defined and enforceable water quality target (for example: maximum permissible loads of phosphorus –US TMDL) –equivalent to the cap in a cap and trade system

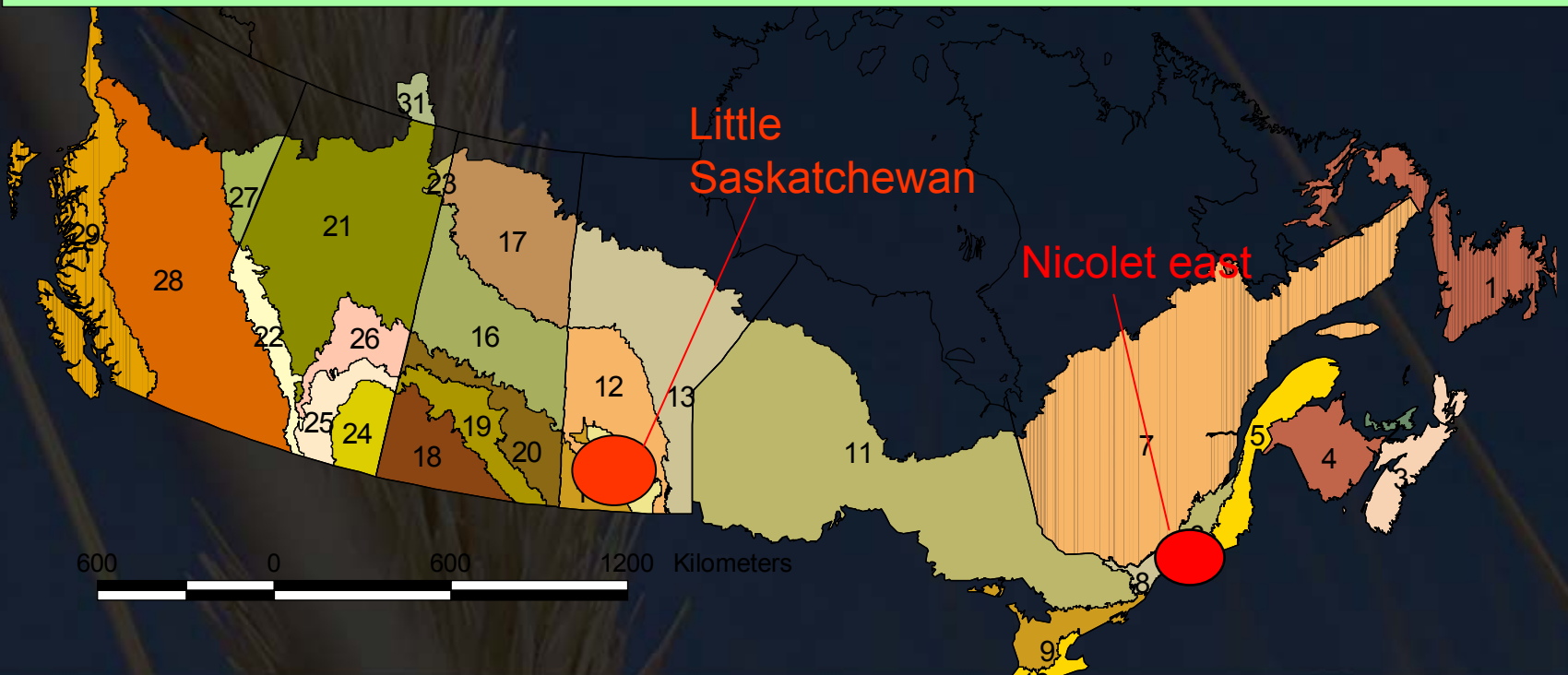
Choice of representative watersheds

Criteria

1. Geographical position
 - ✓ Watershed in an agricultural region
2. Size of the watershed
 - ✓ > 1 500 km²
3. Agricultural production
 - ✓ More of 30 % of cultivable land
4. Diversity of agricultural production
 - ✓ Animal density (Crop density for Manitoba)
5. Environmental issues related to agriculture
 - ✓ Actual levels of indicators below target levels
6. Availability of data
 - ✓ Readily available

2006 FEMS Proposed geographies

- | | | | |
|---|---|---|------------------------------|
|  | 1. NFLD: BorealShield |  | 16. SK: Boreal Plains |
|  | 2. PEI: Atlantic Canada |  | 17. SK: Boreal Shield |
|  | 3. NS: Atlantic Canada |  | 18. SK: Brown Soil Zone |
|  | 4. NB: Atlantic Canada |  | 19. SK: Dark Brown Soil Zone |
|  | 5. QC: Atlantic Canada |  | 20. SK: Black Soil Zone |
|  | 6. QC: St.Lawrence Lowlands |  | 21. AB: Boreal Plains |
|  | 7. QC: Boreal Shield |  | 22. AB: Montane Cordillera |
|  | 8. ON: St.Lawrence Lowlands |  | 23. AB: Boreal Shield |
|  | 9. ON: Manitoulin-Lake Simcoe-Frontenac |  | 24. AB: Brown Soil Zone |
|  | 10. ON: Lake Erie Lowland |  | 25. AB: Dark Brown Soil Zone |
|  | 11. ON: Boreal Shield |  | 26. AB: Black Soil Zone |
|  | 12. MB: Boreal Plains |  | 27. BC: Boreal Plains |
|  | 13. MB: Boreal Shield |  | 28. BC : Montane Cordillera |
|  | 14. MB: Black Soil Zone |  | 29. BC: Pacific Maritime |
|  | 15. MB: Lake Manitoba Plain | | |



Choice of priority EG&S

- Swinton et Zhang (2005)

“EG&S represent the benefits that human populations derive, directly or indirectly, from healthy functioning, and evolving ecosystems, which encompass air, water, soil, and biodiversity”

Table 1. Ecosystem services recognized in recent literature*

| | 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 genetic 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.

Choice of EG&S

- Criteria:
 1. Quantifiable biophysical changes
 2. Significant biophysical changes
 3. Perceivable public impact

| <u>EG&S</u> | <u>Parameters</u> |
|---|-------------------------------------|
| Conservation/Restoration of water quality | - Phosphorus concentration in water |
| Conservation/Restoration of biodiversity, wetlands, aquatic ecosystems and other wildlife habitat | - Wetland area - Forest area |

Current and target Levels

| | Nicolet – Quebec (Eastern and Central Canada) | Little Saskatchewan River – Manitoba (Western Canada) |
|--|--|--|
| <u>Water quality</u> | | |
| → Phosphorus (TP) | <ul style="list-style-type: none"> ◦ Target level: 0.036 mg/l (share of agriculture from the general target of 0.03 mg/l) ◦ Baseline/Current level: 0.041 mg/l | <ul style="list-style-type: none"> ◦ Target level: 0.05 mg TP/L ◦ Baseline/Current level: 0.20 mg /l |
| <u>Wildlife habitat quality</u> | | |
| → Wetland areas | <ul style="list-style-type: none"> ◦ Maintaining existing wetlands Baseline : 2,72% ◦ Expanding the area of wetlands by reducing cropping on floodplains | <ul style="list-style-type: none"> ◦ Expanding the area of wetlands Baseline: 6.5% |
| → Woodland areas | <ul style="list-style-type: none"> ◦ Maintaining existing woodlands Baseline: 45% | <ul style="list-style-type: none"> ◦ Expanding the area of woodlands Baseline: 28.8% |

Choice off BMP'S

Habitat - Fairly straitforward

Phosphorus : Selection process

- List of standard BMPs (Riparian buffer zones, cover crops, Zero-till, Manure storage, livestock access to water, milkhouse wastewater, nutrient management, fragile land retirement)
- BMPs for which information is available
- BMPs for which there exist removal coefficients (South-Nation removal coefficients –Lower Boise)

Choice of BMPs

| | Water quality (phosphorus) | Habitat (wetland and woodland) | |
|--------------------------------------|--|---|--|
| | | Wetlands | Woodland |
| Nicolet (Quebec) | <ul style="list-style-type: none"> • Riparian buffer zones (wooded and grassy, 10 m.) • Winter cover crops (for cereals and corn) • Conservation tillage (no-till and reduced till) | <ul style="list-style-type: none"> • Removing lands prone to flooding from production • Conservation of existing wetlands in agricultural zones | <ul style="list-style-type: none"> • Conservation of existing forests in agricultural zones |
| Little Saskatchewan River (Manitoba) | <ul style="list-style-type: none"> • Wooded riparian buffer zones (10 m.) • Converting marginal farmland to wetlands • Winter cover crops • Conservation tillage (no-till) • Manure storage | <ul style="list-style-type: none"> • Converting marginal farmland to wetlands | <ul style="list-style-type: none"> • Wooded riparian buffer zones (10 m.) |

BMPs adoption rates VS environmental targets

- Each portfolio of BMPs reaches the water quality and habitat targets
- One time payment- BMPs involving initial investment only
- Annual payments – BMPs involving annual costs
- Mixed one time/annual payments: BMPs chosen based on their efficiency
- Market instruments –BMPs chosen based on their efficiency – Producers receive their real costs – superior adoption rates
- Adoption rates : based on consultation with regional government agronomist(realistic) except when portfolio does not reach target – target forcing

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 off 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% | - | - | | |

Public costs of policy implementation

- Public costs = Payments to farmers + government transaction costs
- Payments to farmers:
 - Opportunity costs (net margin and rental rates for forest and wetland conservation)
 - Implementation costs –each BMP
 - Maintenance costs –each BMP
 - Private transaction costs
- Transaction costs: % of total payments

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 Nit) | 0.55 | 0.32 |

Public transaction costs of the various policies

| Policy | Public transaction costs (% disbursements) (Nicolet-east) | 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 |

Monetary values of environmental targets (benefits)

- Benefit transfer – Meta – analysis
 - Thomassin and Johnston (2008) for surface water quality
 - Borisova-Kidder (2006) for wetland and terrestrial habitat.
- Results are the same order as Thomassin and Johnston (2008) and Olewiler (2004)
 - around \$10 per household per year for the Nicolet-East watershed, and \$19 per household per year in the Little Saskatchewan River watershed

Comparison of the five policies (B/C)

- ✓ Comparison is on basis of B/C ratios
- ✓ Ratios for water quality < habitat
- ✓ Ratios for Little Saskatchewan < Nicolet-East
 - Benefits/household superior but small population
 - Habitat benefits less important
- ✓ Ratios for annual payments are the least interesting

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 | - |

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) |
| 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 |

B/C ratios further considerations

- Market based instruments perform better even as policy costs are higher.
- Auctions seem to offer the best performance
- Permit trading offers very interesting potential but limited to water quality (in this context) and certain circumstances.
 - Payments not funded by government
- Mixed instruments seem preferable than one time

Extrapolation off benefits and costs

Scaling up:

Nicolet-East watershed  Central and Eastern Canada

Little Saskatchewan watershed  Western Canada

Basis: all agricultural watersheds off the two regions

*Because of data limitations, quality and time constraints:
Consider only ballpark figures*

BENEFIT/COST RATIOS FOR CENTRAL AND EASTERN CANADA

| | One-time payments | Annual payments | Mixed one-time/annual payments | Auctions | Tradable permits (for P only) |
|--|-------------------|-----------------|--------------------------------|----------|-------------------------------|
| \$ millions | | | | | |
| (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 | - |
| \$ millions | | | | | |
| (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 | - |

Ratio of environmental benefits obtained /Total costs in Western Canada

| | One-time payments | Annual payments | Mixed one-time/annual payments | Auctions | Tradable permits |
|---|-------------------|-----------------|--------------------------------|----------|------------------|
| (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 |
| (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 |

Major conclusions

- Generally , there seems to be enough public benefits to justify the costs. The important question is how to get better efficiency through policy design.
- 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
- 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

Major conclusions

- Policies based on market-based instruments (auctions and permit trading systems) are more efficient.
 - Even if they entail higher public transaction costs
- The analysis was based on two representative watersheds: the Nicolet (East) sub-watershed in Quebec and the Little Saskatchewan River watershed in Manitoba.
 - What would be a more appropriate number of representative watersheds to have a better picture
- The environmental benefits analyzed 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.
 - Chosen because of data limitations - indicators.
 - Do not consider Carbon sequestration, landscape, etc. EG&S

And in the end

A few observations

- We learned more in doing the exercise and reaching the intermediate outcomes than the overall results suggests.
- The information and knowledge infrastructure (water quality, habitat, etc.) is poor not to say the least
- Scaling up is a risky endeavour but a necessity for policy making – it is often left at the end of the study process- should be given more attention

And in the end

A few observations

- Market based instruments offer the most significant improvement in efficiency over traditional policy design
- Market based instruments offer additional co-benefits :
 - They are intensive on basic information (Technical , bio-physical) – Co-benefit off implementing these mechanism
 - They concentrate the attention on the environmental results (and how they are defined)
 - The focus is on the appropriate scale off implementation and the institutions involved.
 - In trading scheme, the funding for the payments to farmers is shifted to the market (point sources)
 - They open the door to innovations (institutional mechanism and technology)

QUESTIONS?

Presentation made by Claude Sauvé
with support off Maria Olar