CHAPTER 19. THE CANADIAN SHELTERBELT PROGRAM: ECONOMIC VALUATION OF BENEFITS

Suren Kulshreshtha, Edward Knopf, John Kort, and Julie Grimard[1]

Abstract

The Shelterbelt Centre was created to provide suitable planting materials (trees and shrubs) for wind protection on the Prairies. Its two main activities are the growing and distribution of seedlings, and research, development and technology transfer related to shelterbelts. This ex post evaluation made a comprehensive effort to estimate the social environmental benefits generated by the Shelterbelt Program. Social environmental benefits generated by each of the two main activities were estimated using a three-stage approach and based on a use-related valuation of benefits. Social benefits that could be estimated ranged between CAD 105 million and CAD 600 million over 1981-2001. Not all identified benefits could be valued, primarily on account of data and information gaps connecting shelterbelts with human well-being. This estimate compares favourably with Program costs ranging between CAD 13 million and CAD 19 million for the same period. Limits relating to tools/methods and data requirements were identified to improve our understanding of the challenges of conducting this type of evaluation. Some challenges could have been reduced if an evaluation framework had been developed at the inception or during the life of the Program to improve the collection of data required, but most social benefits are likely to remain intrinsically difficult to estimate.

Introduction

An *ex post* evaluation of the Canadian Shelterbelt Program was recently conducted, with the primary objective of assessing social benefits generated by the Program. Social benefits of agri-environmental programmes are often not assessed due to challenges related to tools/methods and availability of data. This evaluation was successful in assessing some of the social benefits generated by the Program and has also improved our understanding of the methodological challenges of conducting this type of evaluation.

Description of the Program

The Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration (AAFC-PFRA) Shelterbelt Centre was established in 1901. Since its inception, the Centre has been involved in two groups of activities. The first group is the growing and distribution of tree and shrub seedlings for

1. Suren Kulshreshtha and Edward Knopf are at the University of Saskatchewan. They prepared the report *Benefits from Agriculture and Agri-Food Canada's Shelterbelt Program: Economic Valuation of Public and Private Goods* for Agriculture and Agri-Food Canada, with the assistance of John Kort, of the Shelterbelt Centre. This paper is primarily based on this report and was prepared by Julie Grimard, Agriculture and Agri-Food Canada, with the assistance of the authors. Copies of the full report are available from John Kort (kortj@agr.gc.ca).

planting shelterbelts on farms and other eligible sites. The second group of activities is comprised of research, development and technology transfer (RDTT) related to shelterbelts. To a certain extent these two groups of activities are complementary, since more technology transfer activities can be postulated to arouse interest among the landowners to decide to plant shelterbelts, and research into suitable shelterbelt varieties, design and management improves overall performance.

By the end of 2002, in the three Prairie provinces of Alberta, Saskatchewan and Manitoba, an estimated 576 million tree and shrub seedlings had been distributed to over half a million users/agencies, although some of them are repeat customers. In a typical year, the number of tree and shrub seedlings distributed by the Centre has varied between 4 and 12 million, with the average for the entire period being 5.65 million per year. The Shelterbelt Centre provides tree and shrub seedlings at no cost to farmers and other types of clients.

The most common types of shelterbelts planted in the Prairies are to protect farmsteads from extreme climatic effects (strong winds), to reduce damage by wind in farm fields (soil erosion and crop damage) and to reduce risks caused by wind along roads (snow drifting and road blockage). Of the total number of tree and shrub seedlings distributed by the Centre over the 1981-96 period, the largest share (88.6% of the total) was received by landowners for planting field and farmstead shelterbelts. The remainder of the seedlings were distributed to other eligible clients, mainly wildlife agencies and federal, provincial and municipal agencies.

Scope of the evaluation

The purpose of this study is to better understand the benefits generated by both groups of activities undertaken by the Shelterbelt Program. The major objectives were four-fold:

- To identify and describe qualitatively various private benefits (positive or negative) received by producers from various past and current activities related to growing and distribution of tree and shrub seedlings;

- To quantify benefits to the society at large of the past and current activities related to growing and distribution of tree and shrub seedlings;

- To quantify or describe qualitatively benefits from research, development and technology transfer; and

- To identify the knowledge and information gaps in the estimation of the above benefits, and suggest avenues for further research in these areas.

The major focus of this study was on the second objective. External benefits generated by the shelterbelts to the society were identified and valued, to the extent possible under the constraints of data availability. A detailed analysis was undertaken for trees and shrubs planted during the 1981-2001 period.

Conceptual framework

The total value of the Shelterbelt Program for the period 1981-2001 was estimated as a sum of all benefits derived from the two groups of activities undertaken by the Centre. Private and social benefits could be generated by these activities, and their values can be estimated from a use-based approach.

Private and social benefits

Total benefits of the Shelterbelt Centre activities were postulated to be received by two major groups: Those who plant them, and those who do not plant them but still receive some benefits from them indirectly. The first group of benefits is labelled "private benefits" and the second one as "external benefits" or "externalities", also called "social benefits". External or social benefits are a sum of two sub-categories of benefits: those provided through generation of public goods (called public-goods-related externalities), and those provided by non-public goods (called non-public-goods-related externalities). Public goods are a special category of social benefits and must satisfy two characteristics; one, no one can be excluded from enjoying these benefits; and two, just because someone has enjoyed these benefits, it should not diminish the level of benefits received by other users. In this study, any external benefit that does not satisfy these two criteria is labelled as a non-public-goods-related externality.

Use-based values

A benefit received by a member of the society is the economic value of the impact (change) that is generated by the shelterbelt either directly or indirectly through ecosystem functions. There are at least two schools of thought on this subject. One school, called the utilitarian school, believes that a change in ecosystem functions has value only if it affects the human well-being of members of society. This is the anthropocentric view of the ecosystems. According to this school, ecosystems are here to serve mankind, and only through that process do they have a value. This view is not shared by another school of thought, called the non-utilitarian (ecocentric) school, which believes an ecosystem has an intrinsic value by itself. Since these intrinsic values are very culture and political system specific, they are difficult to estimate and therefore, not attempted in this study. This should not be interpreted to suggest that intrinsic values are not relevant to the society. They may be more important than the anthropocentric values. However, there is a general lack of methodologies to estimate such values. Therefore, in this study, the focus is on social benefits estimated using the anthropocentric school of valuation (use-based value).

Methodology

A two-part methodology was developed to assess the benefits generated by each of the two groups of activities undertaken by the Shelterbelt Centre. Data requirements for the two types of activities are somewhat similar yet different. Since total benefits from the Centre is a sum of these two activities, one of the foremost considerations in this process was to avoid duplication (double-counting) in their estimation. The main guiding principle for these estimates was the "marginality" concept implicit in the "with and without" framework for the study. This principle requires that the change in benefits is measured solely as a result of the shelterbelts.

The growing and distribution of tree and shrub seedlings

For the first set of activities, a three-stage approach was adopted to assess the economic value of benefits generated by the shelterbelts. In the first stage, physical descriptors of shelterbelts on farms were required; this information was provided by the Shelterbelt Centre. In the second stage, an investigation of bio-physical changes that generate various benefits to the society was conducted, including their impacts on humans. The nature of these changes and impacts was based on a review of the literature. The third stage placed an economic value on the identified changes. These values were also selected by using a review of the literature, further refined by using the method of benefit transfer.

Some of the direct social/economic impacts of the shelterbelts on society are felt through commercial activities. These are the easiest ones to measure, since the marketplace provides society's valuation, making estimation relatively simple. However, a majority of direct impacts cannot be valued through the use of market prices, and some alternative methods, commonly called non-market goods valuation methods, are needed. Since these are not traded in a marketplace, their valuation is done indirectly through peoples' willingness to pay for the good or their willingness to accept compensation for the loss of benefit.

Application of the above set of methods required site-specific information on values. Since this has resource implications, a common practice is to use the *benefit transfer* method. In this method, the value of goods and services (primarily those from the natural ecosystems) is estimated by transferring available information from studies that have already been completed but for other locations and/or contexts. Efforts were made to select those that are more relevant to the case in point. Such methods are typically used when it is too expensive and/or there is too little time available to conduct an original valuation study.

When social benefits could be estimated, the net present value (NPV) of benefits generated over the life of trees and shrubs (50 years) planted during the 1981-2001 period was calculated. Discounted numbers are in 1981 Canadian dollars using a discount rate of 10%.

Research, development and technology transfer

A three-stage approach was also used for the second set of activities. The first stage was to describe the nature of RDTT and related activities. This information was collected through preliminary discussions with scientists at the Shelterbelt Centre. The second stage was to develop and use an analytical framework to examine the various programmes/activities, including activity description, outcomes, social benefits, private benefits, and effect on tree/shrub distribution under the Shelterbelt Program. These data were provided by the Centre. Finally, in the third stage, various benefits (private or social) were listed qualitatively. Using the criteria of avoiding duplication with benefits generated from the shelterbelts, certain benefits were identified as additional benefits.

Summary of results

Benefits generated by the first group of activities conducted by the Shelterbelt Centre were identified and estimated, when possible, and results are presented in this section. Benefits were divided according to whether they were generated through ecosystem functions, or through economic and social changes. It should be noted that ecosystem function-related changes result in social and economic impacts that lead to further social benefits. Thus, some benefits are direct in nature, while others are indirect.

The ecosystem function benefits induced by shelterbelts include the following bio-physical changes:

- ***Soil***
  - Reduced soil erosion
  - Shoreline protection

- ***Air***
  - Reduced odours from animal production sites
  - Reduced pesticide drift (also affecting water quality indirectly)
  - Reduced greenhouse gas accumulation in the atmosphere
- ***Water***
  - Increased water quality through filtering function
  - Improved floodplain management
  - Improved wastewater management
- ***Biota***
  - Improved wildlife habitats
  - Improved wildlife based recreation
  - Increased biodiversity

In addition, the following direct socio-economic changes were identified:

- ***Economic***
  - Increased energy conservation
  - Improved aesthetic and related amenities
  - Improved farm level economic efficiency
  - Improved transportation infrastructure related and traffic related impacts
  - Improved health impacts
- ***Social***
  - Improved quality of life.

At least theoretically, each of the ecosystem function changes and socio-economic changes could result in private benefits as well as social benefits (both public-goods-related and non-public-goods-related). For example, reduced soil erosion is likely to have positive impacts on land productivity (private benefits) and also to reduce the cost of cleaning ditches and traffic accidents (social benefits).

As noted previously, private benefits were identified but not estimated quantitatively with one exception (Table 1). Since most benefits are treated in a qualitative manner, the only observation that can be made is that shelterbelts seem to generate large benefits to the producers mainly through reduced energy costs and improved crop production because of reduced soil erosion. A survey of landowners supported this conclusion. Private benefits seem to compensate largely for the private costs related to planting and maintenance of the shelterbelts, as demand for tree and shrub seedlings has been strong since the inception of the Program.

The social benefits through public goods and non-public goods that could be estimated ranged between CAD 105 million and CAD 600 million for the 1981-2001 period (Tables 2 and 3,

respectively). Valuation of public-goods-related benefits could be undertaken for reduced soil erosion (CAD 8-122 million); improved air quality (CAD 4 million); reduced greenhouse gas accumulation (CAD 56-417 million); improved water quality (CAD 1.2 million); improved biodiversity (CAD 5-16 million) and improved energy conservation (CAD 0.2-9.9 million). Valuations of non-public-goods-related benefits that could be undertaken were an increase in consumptive wildlife-based recreational activities (CAD 29 million) and an increase in bird watching activities (CAD 2 million). Some non-public-goods-related benefits were not included as they were already counted in public-goods-related benefits.

Several benefits could not be estimated on account of poor data or lack of evidence on the connection between shelterbelts and human well-being. Evidence either on the biophysical changes or values related to the social evaluation was commonly lacking. In these cases a qualitative evaluation of the benefit was undertaken. For example, although social benefits were considered to be significant, no economic valuation could be provided for improved air quality through odour reduction and health related benefits. Since these social benefits could not be estimated, it is supposed that total social benefits generated by the Shelterbelt Program exceed the total level of benefits indicated in this study.

For the second group of activities (RDTT), a qualitative appreciation of these benefits was made. Even though most of these benefits are considered to be included with those of the first activity of the Centre, some benefits could not be captured such as the generation of knowledge for policy making, benefits to non-farm agencies (nurseries) in North America, benefits from plastic mulch, and knowledge of trees and shrubs and their environment. Overall, it is expected that public-goods-related benefits from RDTT were significant and that non-public-goods-related benefits were moderate.

Social benefits that could be estimated compare favourably with public costs of the Shelterbelt Program. Annual Program costs related to the first set of activities of the Centre averaged CAD 1.5 million over the 1981-2001 period, with total discounted costs for the period ranging between CAD 13 million to CAD 19 million.

Data and information gaps

Some of the benefits could not be estimated, primarily on account of many data and information gaps connecting shelterbelts with social benefits. Data deficiencies are summarised in Annex 1. Major gaps were found in terms of studies undertaken for the Canadian Prairie provinces. Studies dealing with bio-physical changes (with the exception of carbon sequestration) as well as society's valuation of these goods and services were the critical gaps. The list in Annex 1 is by no means a complete and comprehensive one. During the course of undertaking future studies to remove these data deficiencies, it is conceivable that other topics would be added.

Table 1. Private benefits from the growing and distribution of tree and shrub seedlings by the Shelterbelt Centre during 1981-2001[1]

Pathway	Biophysical Impact	Level of Benefits (millions CAD)	Level of Confidence
Soil	Reduced soil erosion	High (affects farm level productivity)	High
	Shoreline stabilisation	May be significant for some farmers (N.E.)	
Air	Odour reduction	May be significant on livestock farms and intensive livestock operations (N.E.)	
	Air quality (non-odour related)	May be important (N.E.)	
	Improves air quality through reduced pesticide drift	None	
	Reduced greenhouse gas accumulation	None (except if carbon credits are available)	High
Water	Water quality	N.E.	
	Salinity reduction	N.E.	
	Floodplain management	May be important for farms located in valleys (N.E.)	
	Wastewater management	None	
Biota	Biodiversity	None directly	
	Consumptive wildlife based recreation	May be important (included under social benefits)	
	Bird watching	May be important (included under social benefits)	
Socio-economic	Energy conservation	CAD 46 - CAD 341	Medium
	Property values	Likely significant	Low
	Farm level production activities	Very highly significant	High
	Transportation activities	Likely low to medium (N.E.)	Low
	Health impacts	May be important (included under social benefits	
RDTT		Medium (through reduced cost of maintenance of shelterbelts on farms)	Low
Total Benefits		CAD 46-CAD 341 + unquantified benefits	

Notes:
N.E. = Not estimated.
1. With the exception of energy conservation there was no attempt to quantify these benefits.

Table 2. Social public-goods-related benefits from the growing and distribution of tree and shrub seedlings by the Shelterbelt Centre during 1981-2001

Pathway	Biophysical Impact	Level of Benefits (millions CAD)	Level of Confidence
Soil	Reduced soil erosion	CAD 8–CAD 122 (includes non-public-goods-related benefits)	Low
	Shoreline stabilisation	Likely low (N.E.)	
Air	Odour reduction	Significant (N.E.)	
	Air quality (non-odour related)	CAD 4 (likely duplication with reduced soil erosion) (includes non-public goods-related (N.E.)	Low
	Improves air quality through reduced pesticide drift	Captured under water quality (N.E.)	
	Reduced greenhouse gas accumulation	CAD 56–CAD 417	High
Water	Water quality	CAD 1.2	Low
	Floodplain management	Likely low (N.E.)	
	Wastewater management	Likely low (N.E.)	
Biota	Biodiversity	CAD 5–CAD 16	Low
	Consumptive wildlife-based recreation	None	
	Bird watching	None	
Socio-economic	Energy conservation	CAD 0.2–CAD 9.9	Medium
	Property values	None	
	Farm-level production activities	None	
	Transportation activities	None	
	Health impacts	Likely of medium significance (N.E.)	
RDTT		Significant	
Total Benefits		CAD 74–CAD 570 + unquantified benefits	

Note:
N.E. = not estimated.

Table 3. Social non-public goods-related benefits from the growing and distribution of tree and shrub seedlings by the Shelterbelt Centre during 1981-2001

Pathway	Biophysical Impact	Level of Benefits (millions CAD)	Level of Confidence
Soil	Reduced soil erosion	Included under public goods	
	Shoreline stabilisation	None	
Air	Odour reduction	Significant (N.E.)	
	Air quality (non-odour related)	Significant (N.E.)	
	Improves air quality through reduced pesticide drift	Included under public goods	
	Reduced greenhouse gas accumulation	Included under public goods	
Water	Water quality	Included under public goods	
	Floodplain management	Likely low (N.E.)	
	Wastewater management	(N.E.)	
Biota	Biodiversity	(N.E.)	
	Consumptive wildlife based recreation	CAD 29	Medium
	Bird watching	CAD 2	Low
Socio-economic	Energy conservation	Likely low (N.E.)	
	Property values	Likely low (N.E.)	
	Farm-level production activities	None	
	Transportation activities	None	
	Health impacts	Significant (N.E.)	
RDTT		Medium (N.E.)	
Total Benefits		CAD 31 + unquantified benefits	

Note:
N.E. = not estimated.

Future research agenda

Future research in this social and private evaluation of benefits needs to be conducted by an interdisciplinary team. Many of the issues society faces in evaluating the private and social benefits suffer from a lack of multi-disciplinary approach to research questions. To build a multi-disciplinary approach, researchers would require a joint effort in formulating the hypotheses to begin with. It is at this point that both the social and scientific information needs are identified and research design formulated accordingly. Shelterbelts are an important resource to the Canadian society; they benefit landowners as well as other members of the society either directly and/or indirectly. A multi-disciplinary approach to generate hypotheses would in itself generate numerous interesting research areas.

Based on this study, the following research activities in the area of valuation of social benefits appear to be good candidates:

Study One: Valuation of social benefits from research and demonstration activities

The major issue to be investigated here is "Why does society support research?" Often, there are no direct commercial outcomes to justify expenditures. This requires a theoretical framework to evaluate significant advancements made by the Centre. To date endogenous economic growth theory lends the most promising clues to the value of research. In addition, this project should also trace the impact these activities have had on other agencies or commercial enterprises.

Study Two: Energy use related benefits from shelterbelts

There needs to be much more research related to energy savings resulting from shelterbelts near farm homes and other buildings. The review found only one study that physically measured this potential with shelterbelts. This study requires an update, since technology of farm home construction has improved significantly since it was undertaken. Furthermore, the link between the hard science and economics is relatively weak. More science is required for differences in energy savings by building types and materials, soil zones, number of protected homes and other buildings, to name a few research areas.

Study Three: Aesthetics-related benefits from shelterbelts

The missing link here is identification of shelterbelts as real estate characteristic. It is possible to do through aerial maps and data sets but would be very time consuming and expensive. This study would be very interesting to undertake to test numerous hypotheses. A number of complicating factors would be: continued rural to urban migration, technological change in production, better crop varieties etc. The question in mind is: Can shelterbelts still claim benefits in face to these changes or are shelterbelt values capitalised into land values?

Study Four: Biota-related recreational benefits from shelterbelts

The links between shelterbelts and recreational activities, such as hunting and bird watching, are very weak or non-existent. A starting point to overcome this would be a survey of users that directly measures hunting or bird watching activities with shelterbelts. While many have claimed such benefits, few have provided the physical link between the two. Part of the problem in the scientific analysis is the common property problem. A shelterbelt may be useful to migrating birds or game

animals which reside in better locations. This requires better analysis to address shelterbelt roles in the large issues of wildlife ecosystem functions before one can address the social impacts. This area of work is new and not fully understood. Much more research is required by scientists to demonstrate the ecological impact on human activities, such as hunting. A greater multi-disciplinary research approach is required.

Study Five: Economic impacts of shelterbelts on agricultural enterprises

One of the problems with the private valuation of shelterbelts in terms is the net benefit calculation. Shelterbelts generate private benefits to producers in terms of improved yields, cost of production and revenue. However, some producers who use practices such as continuous cropping, improved crop rotations, chemfallow, zero till or air seeding suggest that they do not need the services of shelterbelts. Technological changes are now providing some of the shelterbelt services, such as erosion control. More work is required in estimating this trade-off and where exactly the trade-off occurs.

Study Six: Valuation of other non-public goods from distribution of trees and shrubs

The impact of shelterbelts in terms of accident prevention, highway safety or road cleaning is non-existent for Canada. Any analysis would at least start a Canadian body of work on this issue. One needs to first establish the general scope or size of impact that shelterbelts may have in addressing these problems. This may be an activity in cooperation with Departments of Highways and Transportation in various Prairie Provinces.

Study Seven: Social benefits from shelterbelt: soil conservation

This project requires hard scientific data linking shelterbelts to social benefits. Estimates of the amount of wind-eroded soil leaving the farm are lacking, along with its impact on other parties. There are many qualitative assessments of the impacts, but little physical or economic evidence exists. Even more basic is the estimated wind erosion that occurs across western Canada in the past and today. If technological changes in agricultural have reduced wind erosion, the questions remain – what are the current erosion rates, and what are today's impact of shelterbelts?

Study Eight: Examination of future use and non-use values associated with shelterbelts

In this study at the very outset it was decided to narrow the scope of this study down to use related values. Thus, option values and non-use values related to the shelterbelts were excluded. This proposed study should explore the possibility of estimating these values for the prairie shelterbelts. In addition, one of the issues in the context of shelterbelts is to establish whether such values do exist. This may require some personal survey of the users and non-users of shelterbelts. Once such values are conceptually established, the next step would be to develop appropriate methodologies for their estimation.

In summary, reviewed literature demonstrates that shelterbelts provide various ecological services for society from filtering contaminants as a buffer strip, resulting in various activities that make positive contribution to human well-being. Arising from the planting of shelterbelts are numerous social benefits beyond those that accrue to private landowners. This study looked at the social benefits that field shelterbelts provide, and found them to be significant.

Many of the issues that the society faces in evaluating the social and private benefits suffer from a lack of multi-disciplinary approach to research questions. To build a multi-disciplinary approach,

researchers would require a joint effort in formulating the hypotheses to begin with. It is at this point that both the social and scientific information needs are identified and research design formulated accordingly. Setting aside the value of undirected pure research – a multi-disciplinary approach to generate hypotheses would in itself generate numerous unknown and interesting research areas.

Conclusion

This study was undertaken to identify and estimate, subject to data and information availability, various benefits from the two sets of activities conducted by the Shelterbelt Centre – activities related to the growing and distribution of tree and shrub seedlings, and activities related to RDTT.

Economic valuation was limited to social benefits generated by the Shelterbelt Program during the 1981-2001 period. Social benefits were divided in two groups: public-goods-related benefits and non-public-goods-related benefits. Benefits were assessed for their use values only; no attempt was made to assess their intrinsic values.

A three-stage approach, specific to each of the two sets of activities undertaken by the Centre, was developed to assess benefits. Literature reviews were used to investigate bio-physical changes from shelterbelts, impacts on humans and economic valuation. Economic values were refined by using the method of benefit transfer.

Social benefits from the growing and distribution of tree and shrub seedlings were estimated to be in the range of CAD 105-600 million during the 1981-2001 period, mainly due to reduced soil erosion and reduced greenhouse gas accumulation. However, many benefits could not be estimated due to the lack of data, including benefits related to RDTT activities, underestimating total social benefits generated by the Program. These benefits compare favourably with programme costs estimated to range between CAD 13 and CAD 19 million for the same period.

Assessing social benefits is a very complex task, especially because of the lack of appropriate data. Under this study, data deficiencies were mainly for bio-physical changes and economic valuation of benefits. The use of published data to assess potential changes may not adequately reflect specific situations and the shortage of Canadian studies was a significant limit.

This evaluation has made a comprehensive effort to estimate social benefits generated by the Program and identified the challenges of conducting this type of evaluation. Some of these challenges could eventually be reduced if an effort is made early in the life of a programme to develop an evaluation framework. This framework would identify how *ex post* evaluations would be conducted and assess the relevance and feasibility of collecting data, even though the collection of data may not always be realistic or worth the efforts and costs. To a certain extent, the capacity of conducting *ex post* evaluation of agri-environmental programmes could be improved but some benefits, like social benefits, will remain especially difficult to estimate.

ANNEX 1

DATA AND INFORMATION GAPS

Soil erosion

- Physical; magnitude of losses from soil erosion through winds:
  - Magnitude of losses on farms:
    - Building and structures
    - Livestock and other farm animals
    - Gardens and other farm activities
  - Magnitude of losses on other non-farm properties
    - Buildings
    - Household activities
  - Magnitude of increased expenses to local governments
  - Cost of silt removal from reservoirs
- Impact of shelterbelts in reducing damage from wind erosion by location
- Value of losses from wind erosion by location

Shoreline stabilisation and floodplain management

- Data on areas with shoreline instability problems in the prairie provinces
- Nature of riparian shelterbelts planted to protect shoreline, by location
- Nature of benefits under prairie conditions from shoreline protection
- Reduction in flood damage in area with riparian shelterbelts
- Benefits to society and landowners from such measures
- Society's willingness to pay for such measures

Odour reduction

- Data on shelterbelts planted near livestock operations (feedlots, manure storage sites, lagoons etc.) in the Prairie provinces
- Reduction in the odour being emitted from these sites

- Impact of odour on property values in the Prairie provinces
- Impact of odour on health of individuals on farms in these locations
- Impact of odours on health of people residing in the neighbourhood in these locations

Air quality improvements through reduced soil drifts

- Improvement in air quality in areas with severe wind erosion through planting shelterbelts in the Prairie provinces
- Relationship between shelterbelt characteristics and air quality improvement
- Change in property value through improved air quality in the region
- Change in the health related disease incidence in areas with shelterbelts

Air and water quality improvements through shelterbelt plantings

- Regions in the Prairie provinces with problems of pesticide drift
- Impact of pesticide drift on water quality
- Effects of pesticide drift on air quality
- Effectiveness of shelterbelts in reducing the effect of pesticide drift
- Effectiveness of shelterbelts on reducing other water quality degradation
- Impact of reduced air quality from pesticide drift and other water quality degradation on human health
- Magnitude of improved water quality from reduced pesticide drift
- Cost to society from reduced water quality

Carbon sequestration

- Although many of the projects at the AAFC-PFRA Shelterbelt Centre have paid attention to physical level of carbon sequestration, its valuation remains an area where more work is required.
- A more recent inventory of the shelterbelts by type would also improve these estimates

Wastewater management

- Data on rural and urban municipalities where wastewater disposal is expensive and alternative method of disposal would be economically desirable.
- Economics of wastewater management using shelterbelts in different parts of the Prairies

Biodiversity

- Differences in the biodiversity between regions with and without shelterbelts
- Valuation of biodiversity

Consumptive and non-consumptive recreational activities

- Consumptive Recreational Activities
  - Relationship between shelterbelts and type of wildlife
  - Differences in hunting experience in areas with shelterbelts as against in areas without
  - Hunters' willingness to pay extra for the use of shelterbelts
- Non-Consumptive Recreational Activities
  - Relationship between bird habitats and shelterbelts
  - Data on expenditures on bird watching and related activities

Energy conservation

- Data on number of farms and other homes with shelterbelts
- Recent evidence on reduction in home heating cost
- Evidence on reduction in home cooling costs
- Data on type of fuel used for heating and cooling

Property values

- Relationship between presence of shelterbelts in the farmstead and the sale value of the property
- Effect of shelterbelts on farms on properties without shelterbelts but located nearby

Private Benefits

- Although excellent review of studies have been provided by Kort (1988) and Poppy (2003), a synthesis of more recent prairie studies would be helpful

Transportation Sector Related Benefits from Shelterbelts

- Relationship between traffic accidents and presence of road shelterbelts
- Nature of typical damage under wind and snow conditions in the prairie provinces

Health-related benefits from shelterbelts

- Relationship between mental health of individual and presence of shelterbelts
- Other health related incidences (excluding odour related, air quality related and water quality related) from shelterbelts
- Typical corrective expenditures by society for such incidents.

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TABLE OF CONTENTS

Page

Part VI
EVALUATION OF ADVISORY AND INSTITUTIONAL MEASURES

Part VII
EVALUATION OF POLICY MIXES