SOCIAL GOODS IN PRAIRIE SHELTERBELTS

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ABSTRACT

In arid and semiarid regions of the Canadian prairies, shelterbelts can be a highly valuable resource, not only to the producers who plant them, but also to other members of the society. They benefit society through creating various types of ecological goods and services, which are commonly referred as external benefits. The external benefits can be as important as the private benefits received by producers. In this study, the external benefits were estimated for tree seedlings distributed by the Agriculture and Agri-Food Canada Shelterbelt Centre in the Canadian Prairie Provinces for the period 1981 to 2001. Estimation of these benefits required knowledge of biophysical changes caused by such plantings and their valuation. Both of these sets of information were obtained through a search of literature. Estimated benefits amounted to over $132 million (2001 CDN$). A major portion of these were carbon sequestration and reduced soil erosion. Some benefits were identified but could not be estimated on account of data availability. Based on the results of this study, it is recommended that public decision-making for programs should consider both private and external benefits created under such a program. Only then can the overall benefits to society be maximized.

Keywords: shelterbelts, Prairie Provinces, externalities, external benefits

INTRODUCTION

Background

The southern parts of the Prairie Provinces are arid or semiarid and are commonly swept by strong winds in summer and winter. During the period 1857 to 1860, an expedition, led by Captain John Palliser, concluded that these areas were useless as cropland (Lemmen and Dale-Burnett 1999) Although subsequently shown to be wrong, cropland in the so-called Palliser Triangle has commonly experienced wind erosion over the last century and farmers and their families were subject to year-round discomfort and inconvenience because of wind and drifting snow and soil. Tree planting was one of the measures considered essential for agricultural settlement of the area. Although less severe in the parkland areas north and east of the Palliser Triangle, the same problems occurred throughout the agricultural prairies.

The Government of Canada recognized the need for trees by early prairie settlers and established a program in 1901, administered from a federal tree nursery established at Indian Head, Saskatchewan, to provide them with adapted tree and shrub seedlings (PFRA 1978). These seedlings were distributed for use as shelter and fuel. This program continues to operate, administered by the Agriculture and Agri-Food Canada (AAFC) Shelterbelt Centre. By the end of 2002, an estimated 576 million tree seedlings had been distributed based on more than half a million applications including many repeat customers. In a typical year, the number of tree seedlings distributed has varied between 4 and 12 million, with the average for the entire period being 5.65 million seedlings (Figure 1). Further analysis of the total number of tree seedlings distributed over the 1981-96 period, the largest share (88.6% of the total) was used by landowners for field and farmstead shelterbelts.

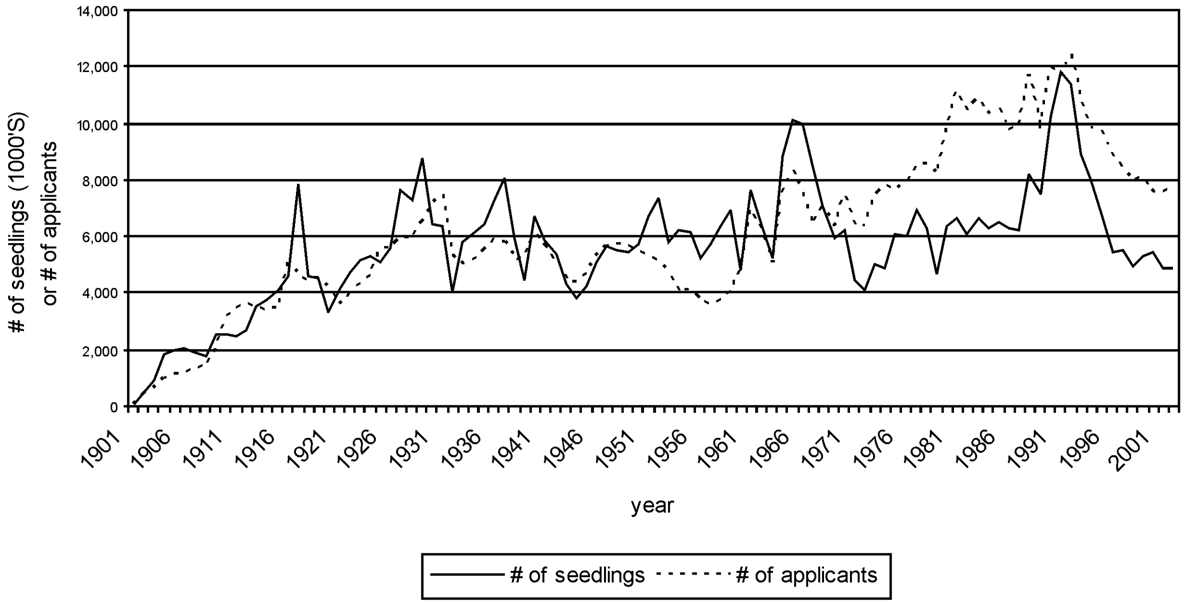

Figure 1. Distribution of tree seedlings by the AAFC Shelterbelt Centre, 1901-2002.

Shelterbelts are multifunctional and have many impacts on landowners and other members of the society. In most cases, the shelterbelts provide multiple benefits so that partnerships between private landowners, government, and nongovernment organizations are desirable in shelterbelt programs to achieve the best overall result. In this way, the AAFC Shelterbelt Program has created economic externalities in the Prairie Provinces. An externality is created if the action of one party brings gains to other parties. If these values can be translated into economic terms, these are called economic externalities. For example, the impact of shelterbelts on society through environmental benefits can be significant by providing a carbon sink, by reducing wind erosion and by other shelterbelt impacts. Each of these is of some value to the Prairie society.

Need for the study

In addition to the original shelterbelt needs, other benefits of shelterbelts are increasingly being recognized by society. In planning for conservation programs, as well as to determine who should provide the funding for such programs, decision-makers require information on the overall impact of the shelterbelts to all members of the society, as well as to the landowners who benefit directly from the trees and shrubs. If benefits of shelterbelts are distributed among all members of the society, the cost of such programs may be shared. If shelterbelts benefits people other than landowners, portion of the cost should be borne by through funds (perhaps various levels of the governments). These results are also important for prioritizing various activities by AAFC's Agroforestry Division.

Kulshreshtha and Kort (2003) presented a literature review on various benefits from the Shelterbelt Centre activities. They concluded that much of the focus in previous studies has been on private benefits, such as yield improvements, feed efficiency gains and higher net incomes. Benefits to other members of society were identified in some studies, but no estimates for the Prairie Provinces were found. This study presents findings concerning some of these external benefits.

OBJECTIVE AND SCOPE OF THE STUDY

The primary objective of this study is to report various external economic benefits that are generated by the shelterbelts in the Prairie Provinces. Major emphasis is on the pathways that result in benefits that accrue to those that do not own or manage the land on which the shelterbelts exist.

CONCEPTUAL FRAMEWORK

The term "benefit" implies that someone is made better off, and that individual has benefited from something. Benefit from shelterbelt is used in this context, where members of the society are made better off by consuming/enjoying/receiving goods and services from planting of shelterbelts by some landowners. This yields an improvement in their economic welfare. In economic literature, and for ease of aggregation, these changes (benefits) are expressed as monetary values.

Such benefits may accrue to individuals through one of two types of economic changes: (1) through improvement in their income (gains in their purchasing power) or (2) through reduced cost of undertaking certain activities, thereby leaving some surplus (income) to be spent elsewhere. Both of these avenues are equivalent and are additive.

As noted above, shelterbelts can generate private as well as external benefits. Private benefits are those that are exclusive to those who own or manage the land or the trees. If crop yields are better in the sheltered area, the increased crop yield is a private benefit to the crop producer. These benefits are well recognized by many landowners and many are scientifically documented (Kort and Brandle 1991) and they are the most important reason that landowners invest time and money into shelterbelt planting. As noted above, these are not investigated any further in this study.

External benefits are created through two types of social goods—pure public goods and nonpure public goods (referred to hereinafter as "nonpublic goods"). Use or consumption of these goods results in public benefits and nonpublic benefits, respectively. These goods are distinguished by the following essential features:

1. Public goods are social goods that accrue to members of society, which have two features:
   - No members of society can be excluded from benefiting from them.
   - If one member of society benefits, the benefit to other members of society is not lessened.

   Wild animals available for photography or aesthetically pleasing landscapes with shelterbelts for enjoyment by people are examples of public good.

2. Nonpublic goods are those that accrue to members of society but which are limited to only a few. Furthermore, if one member of the society uses them, the quantity is diminished for the others to enjoy. Hunting of wildlife is an example of such goods. Use of nonpublic goods is usually regulated through some type of price or charging scheme, which differentiates them from public goods.

External benefits are generated by shelterbelts through the enhancement of ecological goods and services through the protection of soil, air, water, and biota. Some benefits not fitting into these four pathways can be labelled as “Other” category. Those benefits that were quantified are shown in Table 1. A number of other external benefits that could not be quantified, on account of lack of information or poor data, are also listed in Table 1.

Table 1. Identified benefits from shelterbelts.

Source of Benefits	Pathway	Public	Nonpublic
Quantified			
ıced soil erosion	Soil	X	
Reduced greenhouse gas emissions	Air	X	
Protected or enhanced biodiversity	Biota	X	
Energy conservation	Air	X	X
Air quality (non-odour)	Air		X
Water quality	Water	X	
Consumptive wildlife (hunting)	Biota		X
Bird-watching	Biota		X
Not quantified			
Odour reduction	Air		X
Health impacts	Other		X
Aesthetics	Other		X
Transportation activities	Other		X
Wastewater management	Water	X	
Property values	Other (Economic)		X
Pesticide drift	Air/Water	X	

ESTIMATION METHODOLOGY AND ESTIMATED BENEFITS

An overview of the methodology followed in the identification and estimation of benefits from AAFC shelterbelts is shown in Figure 2. All external benefits from shelterbelts are related to the biophysical changes/impacts from the protection of soil, air, water or biota. Using the current state of science, these impacts were translated into impacts on society and are equivalent to benefits. All the information on biophysical changes associated with shelterbelts was based on secondary information that could be obtained during the course of the study. It is recognized that use of site-specific information for estimation of these benefits would have resulted in better estimates of these external benefits. However, every attempt was made in using the benefit transfer approach to reflect Canadian prairie situation.

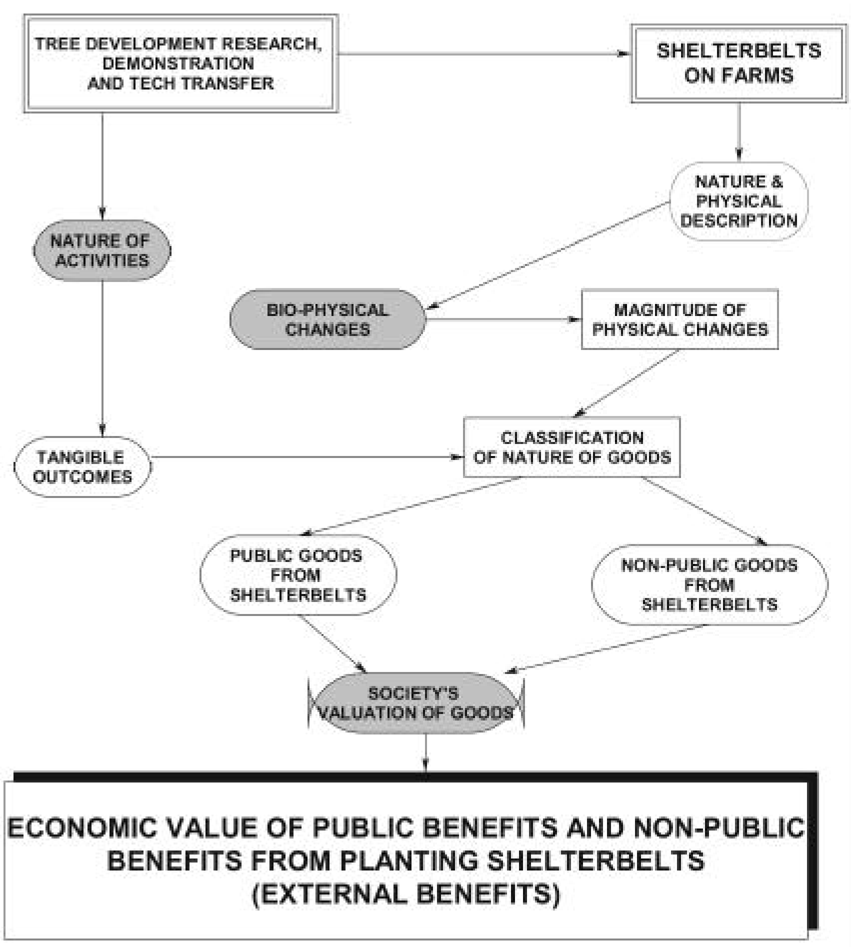

Figure 2. Steps in assessment of economic value of public and non-public goods from shelterbelts. Shaded areas show data and information needs.

In the following section, the methodology followed is described for each identified benefit. More details on these estimates are reported in Kulshreshtha and Knopf (2003). The impacts of shelterbelts resulting from tree seedlings distributed from 1981 to 2001 period were considered. Benefits estimation was limited to this period because the data about tree distribution and use before 1981 were not as reliable.

Reduced soil erosion

Reducing soil erosion creates a combination of private and external benefits. Soil erosion may reduce soil productivity and farm profitability for individual agricultural producers so that reduced erosion creates a private benefit. However, reduced erosion has an important, long-term social benefit. Loss of soil productivity reduces the agricultural value of the land for future generations and may increase the cost of food to consumers. Both of these have an effect on the overall well being of society. In addition, reduced soil erosion also generates other nonfarm-level benefits.

External costs of soil erosion include off-site financial impacts, such as the reduction of air and water quality. As sediment and other erosion-related contaminants enter streams and lakes, they disrupt fish reproduction and feeding, reduce the value of water recreation activities, reduce the capacity of water-storage facilities and navigation channels, affect the preservation of individual organisms, increase the frequency and volume of floods, increase water-treatment costs and maintenance costs of water-using machinery and appliances, and clog water-conveyance systems, such as drainage ditches and irrigation channels (Dickson and Fox 1989). Huszar and Piper (1986) suggested the following external costs related to soil erosion:

1) Secondary impacts associated with reduced production. When farm production is reduced, there is a reduced demand for certain goods and services, such as marketing, processing, transportation and storage.
2) Blowing sand and dust can impair the production possibilities of off-site economic ventures. These may include: (a) machinery maintenance, repair and replacement costs for various businesses; (b) cost of inventory that needs to be kept in a clean condition; and (c) cost of water filtration for various processes.
3) Household consumption may also be affected by blowing sand and dust. The effects on households may come from: (a) damage to structures and buildings and increased cleaning costs; (b) personal costs, including impaired health from blowing dust; and (c) interference with outdoor recreational activities, such as recreational fishing.
4) Government sectors may also be affected through increased cost for: (a) maintenance of buildings and equipment; (b) maintenance of roads, highways, ditches or canals; and (c) water treatment and water utilities.

In order to estimate the external costs, each of these sources of damages (costs) needs to be evaluated. Unfortunately, many of these costs have not been estimated in the context of Canadian Prairies. An indirect method of estimation was therefore pursued.

The benefits from shelterbelts through reduced soil erosion were hypothesized to occur through reducing wind velocity below threshold levels where wind erosion is prevalent. In the three Prairie Provinces, 36% of the cultivated land faces a high to severe risk of wind erosion (Sparrow 1984). Capacity of the shelterbelts to protect a given area has been estimated by Kort (1998) using the Wind Erosion Equation. This resulted in an average of protected area of 26 ha per km of shelterbelts. The total protected area per year was then multiplied by Piper and Lee's (1989) estimated external cost of soil erosion. Converting it to 2001 Canadian dollars, a range of values were obtained. This range was from $0.74 to $4.90 per tonne of soil loss. Since benefits would follow over a period of time, two other assumptions were made: (1) that impact of shelterbelts planted during various time periods is cumulative; and (2) that a net present value was preferable to make them comparable to other benefits. The discount rates used for this calculation were 5% and 10%. Estimated benefits are shown in Table 2.

The reduced soil erosion benefits provided by shelterbelts are estimated to range from $8 to $97 million. The range is large because of the uncertainties related to off-site costs, and discount rates. The challenge for biophysical scientists is to better quantify the soil erosion reduction by the shelterbelt, taking into account soil, climate, and farm practices (tillage and crop rotation), and for the social scientists to account for relevant off-site damages from soil erosion on the Canadian prairies. Since these damages are location-specific, a disaggregated approach has some merit.

Table 2. Estimated Net Present Value of off-site benefits, over a 50-year period, from reduced soil erosion because of prairie shelterbelts.

Abatement Value	NPV of Total Benefits in Million Dollars at Discount Rate	
	5%	**10%**
Low Value ($0.74/tonne)	$14.76	$8.02
High Value ($4.90/tonne)	$97.40	$52.90

Reduced greenhouse gas (GHG) emissions

Reduced GHG emissions related to shelterbelts come in many forms. The following ones are noteworthy:

1) Shelterbelts can sequester carbon in the woody biomass.
2) Shelterbelts replace crop production area and thereby, reduce the amount of farm inputs that produce GHG emissions.
3) Shelterbelts can reduce emissions of GHG by increasing resource use efficiency of sheltered crops in relation to inputs.
4) Future improvements in energy technology may allow shelterbelt biomass to be used as an alternative fuel, thus reducing emissions by nonrenewable fossil fuels.
5) Shelterbelts around farmsteads reduce energy use for heating and cooling, thereby leading to energy conservation and reduced level of GHG emissions.

For this analysis, only the reduced emissions due to shelterbelts because of carbon sequestration, changed land use, and energy conservation were estimated (items 1, 2, and 5 above).

The GHG emissions reduction through carbon sequestration in shelterbelts can be a private as well as a public benefit. If the sequestered carbon in plantations or in harvested woody biomass is sold by the landowner, this value becomes a private value. However, the reduction in net GHG emissions is also of benefit to global society and in this sense it is an external, public goods-related benefit.

In this study, GHG mitigation benefits were estimated using the amount of carbon stored in woody biomass and the value that society may place on this stored carbon. Here lies a great deal of uncertainty. With the pending domestic emissions trading scheme for Canada, price of carbon is currently undetermined. Current trades in the various international emissions trading schemes are of not much help, since the volume is very low and price is heavily discounted. The discount is partly because of the temporary nature of carbon sequestration. Alternative cost of storing carbon can be used as a possible substitute measure of value of carbon.

Total amount of carbon stored in the shelterbelts distributed by the AAFC Shelterbelt Centre was estimated using data on species, age (as reflected in date of shipment), density of planting and the above- and below-ground stored carbon. All the seedlings distributed over the 1981 to 2001 period were estimated to have stored 8.46 Mt (megatonnes) of carbon.

Reduction in GHG emissions from the crop area replaced by shelterbelts was estimated by assuming a shelterbelt width of 5 m and multiplying this by the shelterbelt length to calculate the total area covered, which was 352,230 ha for the 1981-2001 period. Including the reduced emission of methane and nitrous oxide, which have 21 and 310 times the heat-trapping potential of CO_2, respectively, the average GHG emissions were taken as 5.94 tonnes per hectare of CO_2 equivalent (CO_2e). This resulted in a calculated GHG reduction of 229.8 kilotonnes of CO_2e per year. Assuming an average shelterbelt life span of 40 years, 9.2 Mt of CO_2e or 2.5 Mt of carbon were sequestered. (1 gram of C equals 3.66 grams of CO_2)

Determining a range of values for carbon was difficult and this resulted in a large range, depending on the method of estimation for such valuation. The lower end of this range was based on cost of sequestering carbon in developing countries which ranged from $3.36 to $20.16 per tonne in Canadian dollars (C*trade 2003). A median value in these instances was $6.62 per tonne of carbon. The upper end of such values ranged as high as $202 per tonne through geological storage of carbon dioxide (Gunter et al. 1997). The Government of Canada announced a Price Assurance Mechanism—that the maximum cost to be borne by large final emitting companies would not exceed $15 per tonne of GHG (Christoffersen 2003), resulting in a value of stored carbon of $55 per tonne. However, since these stocks are temporary, these prices may be further discounted. The magnitude of this discounting is not known at this time. For these reasons, in this benefit estimation, the model price of $6.62 per tonne of carbon was used. Total benefits were estimated to be $56 million through stored carbon in shelterbelts, and another $16.6 million through substituted cropped area, for a total of $72.6 million. When policy makers in Canada have decided the domestic emissions policy and rules for discounting, the range in the value of stored carbon will be narrowed down.

A third type of benefit from shelterbelts is through reduced energy use, resulting in reduced level of production, and thus, reduced GHG emissions. Assuming a 10% reduction in energy use through the shelterbelts (DeWalle and Heisler 1988; Moyer 1990), estimated reduction in GHG emissions were estimated at 33 kilotonnes of CO_2e or 9.1 kilotonnes of carbon. This value was calculated to be $230 thousand.

Total external benefits from shelterbelts through carbon sequestration are a sum of the above three sources, and are estimated at $72.8 million for the tree seedlings distributed during 1981-2001 period.

Protected or enhanced biodiversity

Biodiversity can be protected or enhanced by shelterbelts at many different levels including soil organisms, plants, arthropods, birds, mammals, and other fauna. Other than consumptive biodiversity-related activities such as hunting, which is discussed later, biodiversity is generally a benefit generated through the consumption of public goods. In other words, it is a benefit to all of society from which nobody can be excluded. Shelterbelts provide shelter, food, and shade for fish, mammals, birds, and insects, although the impact depends on their location (field vs. riparian).

Economic value of biodiversity can be measured either as a value based on anthropocentric framework (it provides some uses for the society) or using ecocentric framework (nature has a value). For some members of the society, biodiversity has very high intrinsic value, which compels them to argue in favour of maintaining or increasing biodiversity in Canada. According to Myers (1997), biodiversity can benefit society through improving existing crops, developing new foods, use for medicines and pharmaceuticals, industrial products, and biotechnology. Unfortunately, studies of the value of services generated by biodiversity are not plentiful, especially for the Prairie Provinces. Scott et al. (1998) reported a value of biodiversity in the US of $52-72 per acre (equivalent to $204-295 per ha in Canadian dollars). Using the lower value of the range and the area under shelterbelts (as estimated earlier), total benefits were estimated at $4.72 million for shelterbelts planted during 1981-2001 period.

Consumptive wildlife (hunting)

One of the anthropological benefits directly connected to shelterbelts is the enjoyment of wildlife such as birds and mammals. These benefits may be consumptive in nature or nonconsumptive in nature. The consumptive nature of the use from wildlife in shelterbelts is from their hunting. It should be noted that the wildlife function of a shelterbelt is contingent upon its location, composition and other biophysical functions it performs.

One of the approaches commonly used for valuing hunting experience, since it is a nonmarket good, is to estimate the hunter's willingness-to-pay (WTP). Recreationalists, such as hunters, are asked to express their payment for making hunting possible (such as bidding for a license to hunt). The bids received, can be averaged and called WTP. However, since this requires surveys (which were considered to be beyond the scope of this study), it is an expensive option. Another method to estimate WTP is the amount of money people are spending for enjoying a certain recreational activity (such as hunting). It is assumed that people's WTP is at least as high as this amount, if not more. Havengaard et al. (1989) have suggested that in addition to costs incurred, there may be some consumer surplus associated with such activities. Such an approach has been equally popular in valuing such experiences. This is the approach followed in this study.

In this study, it was assumed that shelterbelts are associated with deer hunting. Using Environment Canada (2000) per day expenditures for hunting, and number of hunting days obtained from Saskatchewan Environment (pers. comm. 2003), the total economic value of hunting was estimated at $39 and $29 million at 5% and 10% discount rates, respectively.

Bird watching

Shelterbelts are also associated with higher bird population and species richness in the Prairies (Mah 1999). This leads to more participation by members of the society in bird watching. Unfortunately, there is not much information linking shelterbelts with bird watching in the

Prairies and some assumptions needed to be made to arrive at a benefit. Nature Saskatchewan (pers. comm. 2003) was contacted to estimate number of members participating in bird-watching activities. Yearly expenditures for wildlife viewing (including bird-watching) were obtained from Environment Canada (2000). Since these included other activities besides bird watching, it was assumed that 25% of these expenditures are related to bird watching. Using a discount rate of 5%, benefits over the 1981-2001 period were estimated at $1.73 million. Assuming a ratio of cost to total benefits (including consumer surplus) as suggested by Hvenegaard et al. (1989), total benefits to the society from bird watching were estimated at $3.70 million.

Air quality (non-odour) benefits

Trees can have a significant impact on the ambient air quality of the region. Reduction in soil erosion may also lead to reduction in small soil particles, resulting in improved air quality and health related improvements. Using estimates by Kim et al. (2003) and assuming that equal number of households (who did not plant shelterbelts) as those with shelterbelts, are prepared to pay for better air quality, benefits were estimated at $3.71 million. One should note that this estimate is based on a set of assumptions that have not been validated for the Canadian Prairies.

Water quality benefits

Deterioration of water bodies is primarily through runoff from crop production (mainly fertilizer and pesticide drift) and livestock production. Plants and trees near the water bodies (riparian buffers) can filter sediments from agricultural runoff, and slow or disperse flow of water. Trees can also filter nutrient, pesticides and livestock wastes. Through these pathways, shelterbelts can improve surface and groundwater quality.

Improved water quality produces benefits to the society through drinking water as well as for recreational use of water bodies. Value of improved water quality is typically measured as WTP. A number of studies have been undertaken to estimate household's WTP for improved water quality. For the US, the range in estimates has been from $56 to $1,154 (US). For Saskatchewan, Spasic (2002) estimated a value of $39.93 per household for riparian management leading to improved water quality.

Using Spasic's estimate of society's WTP and estimated number of households of 40,553 receiving water quality benefits, total water quality benefits were estimated at $1.21 million.

NOT QUANTIFIED BENEFITS FROM SHELTERBELTS

For some benefits, proper data and information was a major problem. These data deficiencies were either in the form of lack of biophysical changes resulting from shelterbelts or lack of information on the societal value of the biophysical change. In the following sections, these benefits are listed and reasons for their exclusion from this study explained.

Odour reduction: Many studies (Tyndall and Colletti 2000; Griffith 2003) have suggested that livestock production related odours can be dispersed through interaction with shelterbelts.

Associated with these are two benefits: (1) in nonagricultural areas, property values have been suggested to increase; and (2) odour-related health problems can also decrease. A part explanation of excluding these benefits from this study was a lack of data on property values and odour, and on health issues directly connected to them.

Health impacts: Health improvement can be brought about by shelterbelts through several pathways, including the following:

1) Reduction in the odour from intensive livestock operations improves some respiratory disease incidence (as noted above).
2) Reduced air quality through reduced soil particles (called fugitive dust) is associated with diseases such as bronchitis, scatting and production of fibrosis and cancers.
3) Shelterbelts can reduce the occurrence of eutrophication and pollution in water bodies, thereby improving water quality. Algae formed through eutrophication are harmful to humans on contact. In addition, poor quality groundwater is associated in occurrence of blue-baby syndrome (methaemoglobinaemia) and stomach cancer.
4) Shelterbelts, similar to natural areas and forests, can have a positive impact on the mental health of individuals.

These benefits could not be estimated for two reasons: (1) key information on the disease incidence for the Prairies was not available; and (2) some of these benefits may have been captured under the WTP for air and water quality.

Aesthetics and property values: The aesthetic value of a healthy and well-designed shelterbelt around a prairie farmyard is well recognized by society. Producers who plant shelterbelts like them for their aesthetically pleasing view, which is shared with other farmers and public at large. These preferences lead to higher property values, since buyers are willing to pay a premium in price for a pleasing farmyard. In addition, it may also result in decreased amount of time it takes for the property to sell, particularly during period of lower demand for farms. Regional land values are also higher around farms with shelterbelts than in regions without shelterbelts. Some studies in the US have used hedonic price model to estimate these types of values.

This study was not able to find any relevant research literature evaluating the social benefits of shelterbelt aesthetics nor was able to utilize the hedonic pricing method due to lack of data. A brief telephone survey of agricultural real estate agencies failed to find much support for aesthetics-related external benefits from farmyard shelterbelts in terms of land values. However, this is not to say that shelterbelt aesthetics does not have a social benefit through enhanced property values, only that it is somewhat of an unexplored area.

Transportation activities: Social benefits from shelterbelt trees identified by some researchers include things such as: (1) reduced traffic accidents, and (2) reduced cost of cleaning roads and highways. Unfortunately very few studies have been undertaken for Prairie Provinces, or even for Canadian jurisdictions. Much of the literature relating to this aspect of shelterbelts and transportation is from the US and is not necessarily transferable and thus, limited in scope. This section presents the findings that exist and discusses some of the issues relevant to western Canada.

One of the effects of shelterbelts planted in an appropriate manner and in an appropriate location is to reduce the wind speed. During the summer time, this would reduce drifting of the soil (reducing the intensity of dust storms) and during winter, would reduce snow accumulation through its entrapment. Although during drier years, occurrence of dust storms on the Prairies is common, no study has been done to determine its social impact—costs to the society.

In the winter period, shelterbelts can reduce snow accumulation on the roads. In the US, such shelterbelts are commonly referred to as living snow fence. With the reduction of wind speed, snow is deposited and stored in the field rather that drifting on the roadways. Preventive measures, such as this, reduce road cleaning costs and traffic accidents.

No study of linkage between shelterbelts and transportation safety or cost of snow removal was found. Given the vast network of roads and highways, it would be difficult to expect significant number of road mile protected by living snow fences. For this reason, this benefit was not estimated.

Shoreline stabilization: Many farmers and public bodies plant shelterbelts near the water bodies. These shelterbelts can stabilize river banks and shorelines of other water bodies. This would likely lead to reduced silting of the water bodies, which may affect the carrying capacity of the water body for flood protection and for transportation. In addition, silting also affects recreational fishing, as suggested by Dickson and Fox (1989). Water treatment costs for various water utilities are also reduced by the decreased level of silting. This benefit from shelterbelt could not be estimated on account of lack data on various sources of such benefits, and a possibility of double counting with water quality benefits.

Wastewater management: Hybrid poplars are well suited to use agricultural, community and industrial wastewater. If wastewater is used for growing shelterbelts containing hybrid poplars, society would benefit through reduced cost of treatment of such effluent. Unfortunately no scientific data were available for the Prairies to show if this is feasible and what would be the reduction in cost of treatment. For this reason, this benefit was not estimated.

Pesticide drift: Some of the significant airborne sediments are pesticides. Use of such products is very common in agriculture. Besides affecting health of individuals, its major affect is on water quality and through that on the health-related ailments of humans. Water quality in surface water would be affected by a change in the pesticide drift. This would likely result in increased cost of treating municipal water, and if not treated, may result in odour and poor taste, as well as health problems. Unfortunately the magnitude of this problem in the Prairies has not been a focus of any previous study. For this reason, this benefit could not be estimated.

SUMMARY AND CONCLUSIONS

The major objective of this study was to identify, and subject to availability of data (including other information) estimate the external benefits (public and nonpublic benefits) of tree seedlings distributed by the AAFC Shelterbelt Centre. The activity during 1981 to 2001 was taken as the sample period for these estimates.

Estimation of various benefits required knowledge of three key pieces of information: (1) physical descriptors of shelterbelts (when, where, what use, species used, etc.); (2) nature and magnitude of biophysical changes brought about by the above set of shelterbelt uses; and (3) social valuation of benefits perceived by the society in either resulting as either public benefits or nonpublic benefits.

Data on shelterbelt characteristics were obtained from the AAFC-PFRA Shelterbelt Centre. Descriptors of shelterbelts were based on a detailed analysis of 1981-1996 dataset on tree seedlings distribution. Biophysical changes were based on a review of the literature available at the time of writing this report. Similarly the social benefits were estimated by using the method of Benefit Transfer. For some benefits, no studies were found that either identified the magnitude of biophysical change or the level of social valuation. These benefits were simply treated in a qualitative manner.

Estimated benefits from shelterbelts planted with tree seedlings distributed by the Shelterbelt Centre during 1981-2001 period are shown in Table 3. Among those estimated were: reduced soil erosion, increased carbon sequestration, improved water quality, consumptive (hunting) wildlife recreational activities, nonconsumptive wildlife related recreational activities, and energy conservation. In total, public benefits were estimated to be $89 million, and the nonpublic benefits at $43 million, for a total of $132 million.

Existence of external benefits was supported by a survey of attendees at the AAFC-PFRA Shelterbelt Centre Field Day, undertaken in July 2003. Results suggested that individuals, whether they have planted shelterbelts or not, perceived both a high private and social goods from shelterbelts.

IMPLICATIONS AND AREAS FOR FUTURE RESEARCH

Public funding is, for the most part, justified by the widely recognized social benefits. Yet, although they are generally recognized, many of these benefits have not been quantified or monetized in a well-documented way. This prompted the study of value of shelterbelts to the public-at-large. Based on the results of this study, it is clear that shelterbelts generate a variety of benefits to members of the society who have not planted them on their property. This study has established that these benefits can be significant, particularly since a large proportion is available to the public-at-large. Public decision making for funding of various programs should take into account not only the benefits accruing to the users of the service, but also to other members of the society. Only in this manner can one ensure that social welfare (which is the intent of all policies) is optimized.

Unfortunately many of the issues society faces in evaluating the social (private and external) benefits from shelterbelts suffer from a lack of data and information on the likely path to their impacts. A lack of multidisciplinary approach to research questions further accentuates this problem. To build a multidisciplinary 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 multidisciplinary approach to generate hypotheses would in itself generate numerous interesting research areas.

Table 3. Summary of estimated external benefits from shelterbelts through AAFC Shelterbelt Centre activities, 1981-2001, using a 5% discount rate.

Pathways	**Biophysical impact**	**Level of benefits from public goods (Mill. $)**	**Level of benefits from nonpublic goods (Mill. $)**	**Unquantified benefits**
Soil	Reduced soil erosion	$8.0		Shoreline stabilization
Air	Improved air quality (non-odour related)	$3.7		Odour reduction
	Reduced greenhouse gas emissions through carbon sequestration	$56.0		Reduced pesticide drift
	Reduced greenhouse gas emissions through reduced cropped area	$16.6		
Water	Improved water quality	$1.2		Wastewater management
Biota	Biodiversity	$4.7		
	Consumptive wildlife based recreation		$39.1	
	Bird watching		$3.7	
Other	Energy conservation based GHG emissions reduction	$0.2		Aesthetics and property values
				Transportation
				Health impacts
Total Benefits		**$89.4**	**$42.8**	
Grand Total of External Benefits				**$132.2**

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