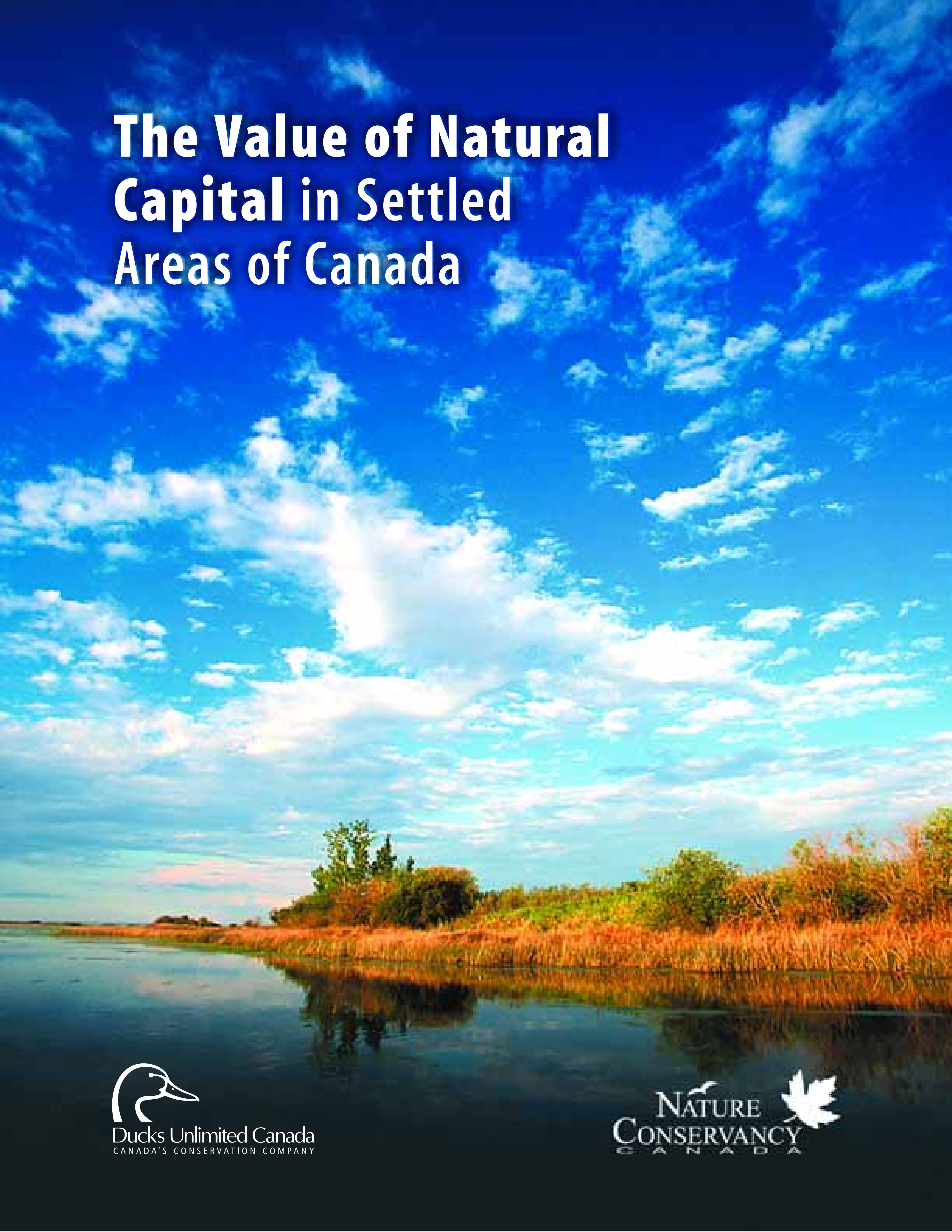
The Value of Natural Capital in Settled Areas of Canada



Ducks Unlimited Canada
CANADA'S CONSERVATION COMPANY

NATURE CONSERVANCY CANADA

foreword

Natural areas within the settled regions of Canada provide numerous goods and services that have economic values, not only for the people within or adjacent to these natural areas but also for the communities farther away. Serving as sources of natural capital, these areas provide such goods and services as clean water supply, water flow stabilization, greenhouse gas mitigation, erosion control, nutrient cycling, genetic resources, biodiversity, pest management, habitat, recreation and cultural pursuits. Yet, these natural areas continue to be lost across Canada. Undoubtedly, this occurs in part because the goods and services provided by natural areas are not precisely known, despite the fact that recent studies outside of Canada suggest that the economic value of these natural areas to society far outweighs any gains from converting them for human uses such as urban development or intensive agriculture.

We believe that efforts to measure, protect, and enhance the natural capital of Canada must accelerate immediately. Therefore, we must: (1) invest in the science to measure, value, and monitor ecological goods and services, and (2) develop economic instruments that recognize and protect natural capital, rather than continue to reward its destruction.

For many Canadians, a primary motivator for habitat conservation is the desire to leave for our children the natural wealth that we inherited from our parents. Therefore, it seems logical that we equate Canada's natural areas with their true economic value and take the necessary actions to safeguard this capital for the future. Will we maintain and build our natural capital for future generations? Or, will we continue to add to the growing debt? We sincerely hope that this paper will inspire recognition and protection of Canada's natural capital.

We believe that the estimates in this paper provide a conservative illustration of the economic values of natural capital from four geographically diverse locations in Canada. Moreover, the case studies reveal that governments, and society in general, may be making inefficient choices when they allocate land to uses that destroy natural capital.

Ducks Unlimited Canada, with the support of the Nature Conservancy of Canada, commissioned Dr. Nancy Olewiler to develop this paper. We are extremely grateful that Dr. Olewiler, an internationally-recognized environmental economist, developed this paper *pro bono* for us.

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The Value of Natural Capital in Settled Areas of Canada*

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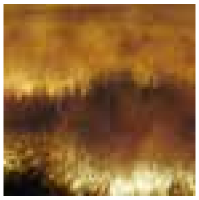

left: Ian McCausland

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executive summary

This paper illustrates the services provided by, and the importance of valuing, natural capital in the settled areas of Canada. Natural capital consists of natural resources, environmental and ecosystem resources, and land. It is capital in the sense that these resources are assets that yield goods and services over time – goods and services that are essential to the sustained health of our environment and the economy. Protection and enhancement of natural capital will improve water quality and decrease water treatment costs, increase recreational opportunities, mitigate flooding, decrease net greenhouse gas emissions, lower dredging costs of waterways, improve air quality, provide habitat, sustain food production and produce many more tangible and intangible benefits to society.

Destruction and degradation of natural capital occurs continually across Canada. Yet, we may not recognize the full value of these losses until it is too late. Case studies in this paper illustrate that governments may be making inefficient choices in allocating land to uses that destroy or degrade natural capital. For example, protecting the existing natural capital in the Lower Fraser Valley may save society hundreds of millions, if not billions of dollars every year. Yet, natural capital continues to be destroyed in this area. The agriculture lands case studies revealed that the estimated net value of conserving or restoring natural areas is about $195/ha/yr in the Grand River Watershed of Ontario, about $65/ha/yr in the Upper Assiniboine River Basin in eastern Saskatchewan and western Manitoba, and about $126/ha/yr in the Mill River Watershed in P.E.I. These case studies reinforce that ignoring the value of natural capital when making decisions about land use will likely result in the degradation and destruction of natural capital and lead to outcomes that are very costly to society both now and into the future.

This paper does not propose specific policies or programs for the protection of natural capital; rather, it identifies that governments have the following important roles to play:

- Provide essential data on the physical quantities and attributes of natural capital and their changes over time. Efficient management of our natural capital resources requires knowing how much we have. No company would stay in business long if its management did not know how much product was being produced, how much it cost to produce it, or the market price for the product. Why should we treat our natural capital – capital that sustains life on the planet – any differently?

- Assist in better decision making by coordinating and funding efforts to measure and value natural capital. Many agencies, public and private, are engaged in measurement and valuation processes. A national clearinghouse for information would greatly assist these efforts.

- On Crown lands, governments should ensure that estimates of the value of the many benefits from natural capital attributes are compared to market values of the land before releasing that land for housing, commercial or industrial uses.

- When land is privately held, governments have a role to play in designing policies that provide incentives for landowners to conserve their land when the value of the natural capital from that land equals or exceeds its value in other uses.

The federal government should take a strong leadership role by creating a national task force to: (1) fund and co-ordinate the comprehensive measurement of baseline data on the state of Canada's natural capital, to estimate its loss over the past decades and to ensure sustained measurement into the future; (2) ensure traditional economic analyses and forecasting approaches are revised to properly account for the services provided by natural capital and integrate the true cost of its degradation with economic decision making.; and (3) to coordinate efforts to conserve and restore natural capital.

No company would stay in business long if its management did not know how much product was being produced, how much it cost to produce it, or the market price for the product. Why should we treat our natural capital – capital that sustains life on the planet – any differently?

ii introduction and overview

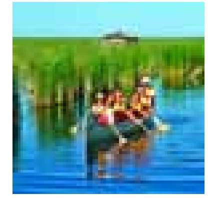
below: Darin Langhorst right: Tye Gregg

Canada is facing a crisis that is largely hidden from most of its citizens. It is the relentless incremental destruction of the natural landscape and the loss of the beneficial services provided by this 'natural capital' – our stock of natural and environmental resources that yields many goods and services over time. Natural capital consists of three components: (1) natural resource capital – stocks of renewable and nonrenewable resources (e.g., minerals and energy, forests, water, fisheries); (2) ecosystems or environmental capital – systems that provide essential environmental goods and services such as our atmosphere and waste assimilation provided by wetlands; and (3) land – the space in which human activities take place. Destruction and degradation of natural capital occurs continually and we may recognize the loss of important ecosystems only after they are gone – a loss that may be irreversible.

When the community benefits from a landowner's decision to sustain a wetland, the landowner has no ready means of capturing the social and economic benefits generated by the wetland.

A major cause of the loss and degradation of natural capital is the conversion of our natural areas to other uses – homes, industries, roads and industrial agriculture. These land uses are of course valuable to society; people need homes, jobs, food, goods and services. But the destruction of natural capital in the form of, for example, loss of forests, wetlands, grasslands and riparian zones leads to not only the loss of the services from this natural capital, but a coincident increase in wastes going into the natural environment. Examples include air pollution from automobiles and industry, water pollution from industrial, commercial, agricultural and household contaminants, soil degradation from erosion due to construction and buildup of fertilizers and toxic compounds.

The conversion of natural landscapes may be inefficient from an economic viewpoint. By destroying natural capital, we must find substitutes for the services this capital provides, services in the form of water purification, waste assimilation, cleansing of the atmosphere, mitigation of greenhouse gas emissions, flood prevention, soil retention, fertility enhancement, alternative recreational services and much more. The substitutes for natural capital may be far more expensive to build and operate than those provided by nature. This is inefficient and costly for society today and for generations to come. As importantly, when decision makers undervalue the benefits from nature, they underestimate the full costs to society of converting land to uses that destroy or degrade natural capital. Left intact the natural capital from the land may generate far more value to society than alternative land uses. Intact natural capital also provides many intangible and hard to quantify benefits to society (for example, protection of genetic material, aesthetic appreciation, wildlife enhancement and much more). Recognition of these benefits by policy makers is another important step in formulating land use policy.



Why does inefficient land use occur? A major difficulty is that private decision makers typically take into account only the market values and personal benefits accruing from the natural capital assets they own and manage. When the community benefits from a landowner's decision to sustain a wetland, the landowner has no ready means of capturing the social and economic benefits generated by the wetland. Hence, the landowner will find it difficult to preserve the wetland, rather than, for example, drain it to use for agriculture or sell to a developer for home construction. We have laws and regulations that apply to private lands (e.g., land use restrictions through zoning, prohibition of building too close to streams and rivers), but regulation to protect the natural capital on private lands is far from comprehensive. Landowners would expect compensation for conserving or enhancing the natural capital on their property when it benefits society and when prior restrictions on land use do not exist. Compensation should cover the opportunity costs of the land – the foregone profits from their next best viable and legal use. Public decision makers face similar dilemmas when assessing development plans for their regions. If they do not recognize the value of the benefits from the goods and services generated by natural capital, they will be more inclined to favour land uses that do generate revenues (for example, property tax revenues and development fees).[2]

What can help reverse the loss of natural capital?

- Government decision makers and the public need to recognize that nature provides valuable services that should be factored into land use decisions to help society make better choices about economic growth. Where lands are public, governments need to adopt land use policies that explicitly take into account the value of nature to society rather than ignore its services and make decisions that may be very costly to society now and into the future.
- Governments need to develop and implement policies that provide incentives for private landowners to make decisions commensurate with valuing not only their own private returns, but also social returns to their land.
- We need to increase our efforts to measure and quantify the services of nature to assist government and individuals to make more efficient land use decisions. A number of federal and provincial government agencies, non-governmental organizations, and individuals are trying to value nature, but their activities are uncoordinated, and no one agency has the budget to undertake this task. A national task force to fund and coordinate these activities could help supply the data and analysis badly needed now by decision makers.

This paper explains the importance of valuing nature. The services provided by Canada's natural capital are described. Case studies illustrate that we may be making inefficient choices in allocating land to uses that destroy and degrade natural capital. Society may therefore have to look for more expensive substitutes or to forego these services at a loss to our well-being today and into the future.

Natural Capital: What it is and what it does

The stock of natural resources, environmental and ecosystem resources and land have been called natural capital – capital in the sense that these resources are assets that yield goods and services over time (goods and services that are essential to the sustained health and survival of our population and economy). Along with human capital and produced or manufactured capital (e.g., machinery, structures), natural capital is an input into the production of goods and services in addition to being enjoyed for its own sake. Table 1 provides a detailed list of the many goods

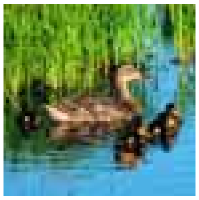


TABLE 1 – Types of Ecosystem Goods and Services

Ecosystem Service	Ecosystem Function	Examples of Services
Atmospheric stabilization	Stabilization of atmospheric chemical composition	CO_2/O_2 balance, stratospheric ozone, SO_2 levels
Climate stabilization	Regulation of global temperature, precipitation and other climate processes affected by land use	Greenhouse gas production, cloud formation
Disturbance avoidance	Integrity of ecosystem responses to environmental fluctuations	Storm protection, flood control, drought recovery and how vegetation structure helps control environmental variability
Water stabilization	Stabilization of hydrological flows	Supply water for agriculture use (irrigation), industrial use or transportation
Water supply	Storage and retention of water	Water storage by watersheds, reservoirs and aquifers
Erosion control & sediment retention	Retention of soil within an ecosystem	Prevention of soil loss by wind, runoff, other processes, storage of silt in lakes, wetlands, drainage
Soil formation	Soil formation process	Weathering of rock and accumulation of organic material
Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients	Nitrogen fixation, nitrogen/phosphorus, etc. nutrient cycles
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess nutrients and compounds	Waste treatment, pollution control, detoxification
Pollination	Movement of floral pollinators	Providing pollinators for plants
Biological control	Regulation of pest populations	Predator control of prey species
Habitat	Habitat for resident and transient populations	Nurseries, habitat for migratory species, regional habitats for locally harvested species, wintering grounds
Raw materials	Natural resource primary production	Lumber, fuels, fodder, crops, fisheries
Genetic resources	Sources of unique biological materials and products	Medicine, products for materials, science, genes for plant resistance and crop pests, ornamental species
Recreation	Provides opportunities for recreation	Ecotourism, sportfishing, swimming, boating, etc.
Cultural	Opportunities for non-commercial uses	Aesthetic, artistic, education, spiritual, scientific, aboriginal sites

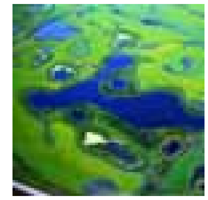
Sources: Amanda Sauer (2002). *The Values of Conservation Easements* discussion paper, World Resources Institute, presented by West Hill Foundation for Nature, December 1, 2002.
Costanza, R. et al. (1997). The Value of the World's Ecosystem Services and Natural Capital, *Nature*: 387: 253-260.

left: Brian Wolitski right: Ian McCausland

and services provided by natural capital. Table 2 illustrates examples of the types of goods and services provided by different types of natural capital.

We do not fully understand all the complex relationships in ecosystems and the precise roles natural capital plays in sustaining life. If science and technology could replicate all of the goods and services provided by these forms of natural capital, society might be more sanguine about the loss of natural capital. We would then substitute other forms of physical and human capital for the natural capital we have used up.[3] For example, when natural waste treatment provided by wetlands, grasslands and forests has been eliminated by their conversion into urban areas, communities can construct water and waste treatment facilities. But is substitution of other forms of capital for natural capital in society's interest? The concern is twofold. First, before substituting produced capital for natural capital, decision makers should ensure that the manufactured substitute replicates all the essential functions of natural capital and costs no more than the natural capital. It is possible that the substitute for natural capital is far more expensive than sustaining the natural capital services. New York City decided that it was far cheaper to pay $1.8 billion to private landowners to protect 80,000 acres in the watersheds providing its drinking water than to spend $8 billion to construct a new water filtration plant. The city not only saved the capital costs of the filtration plant, but also an additional $300 million per year in operating costs.[4] Second, there are many goods and services only natural capital can provide – there are no substitutes.[5] Some forms of natural capital are clearly essential – water and our atmosphere for example. If the protective stratospheric ozone layer is lost, the amount of ultraviolet radiation reaching the earth's surface would exterminate most plant and animal life. We do not know how to recreate our atmosphere or sequester large amounts of carbon dioxide without the use of natural capital.

Like other forms of capital, natural capital can be depreciated. Depreciation of natural capital arises from its depletion or degradation. Examples of depletion include harvesting the resource (e.g., timber harvests, mineral extraction) or conversion of natural ecosystems to other uses (e.g., draining wetlands, paving over grasslands).



When natural waste treatment provided by wetlands, grasslands and forests has been eliminated by their conversion into urban areas, communities can construct water and waste treatment facilities. But is substitution of other forms of capital for natural capital in society's interest?

TABLE 2 – Examples of Ecosystem Services by Ecosystem Type

Ecosystem	Goods and Services Provided
Forests	Carbon storage and sequestration, soil formation, waste treatment, biological control, cultural, air quality, stormwater control, recreation, raw material (timber), genetic resources
Grasslands, rangelands	Carbon storage and sequstration, water regulation, erosion control, soil formation, waste treatment, pollination, biological control, food production
Wetlands	Disturbance regulation, water supply and treatment, food production, recreation, cultural, habitat/refuge, total ecosystem
Lakes, rivers, riparian zones	Water supply, waste treatment, food production, recreation, total ecosystem
Croplands	Food production, habitat/refuge, scenic
Undeveloped lands	Scenic

Adapted from Amanda Sauer (2002), *The Values of Conservation Easements* discussion paper, World Resources Institute, presented by West Hill Foundation for Nature, December 1, 2002.

left: Jeope Wolfe right: Brian Wolitski

Degradation represents the declining quality of the natural capital. An example is the depletion of soil fertility through contamination by pollutants or loss of nutrients. Destruction of natural capital adds costs to society. As noted above, communities either lose directly by having to find substitutes for the goods and services provided by the natural capital, or do without, causing loss in well-being, and in many cases, financial loss. As natural capital is degraded and depleted, the economy's ability to produce goods and services is hampered. Natural capital is thus becoming a limiting factor in sustaining production over time.

Measurement of Canada's natural capital has in recent years focused on stocks of land, energy, mineral and timber reserves. While this is a good start to understanding how much natural capital we have, serious measurement deficiencies exist. Firstly, we have very little data that show the changes in our natural capital over time; and we haven't even identified and measured all the components of natural capital. Secondly, many components of natural capital, particularly the services embodied in natural and environmental resources, are not routinely calculated. This is a difficult task, but made more so by the lack of funding. For example, while we have the technology to measure land use changes over time through satellite imagery, governments in Canada have failed to provide the funding for detailed analysis of the data. This means that we do not know how much natural capital we are losing each year. Governments and society in general cannot make wise decisions about how to sustain production and consumption over time when one of our essential inputs is not being measured. However, even for the forms of natural capital that are more readily measurable (e.g., stocks of minerals, fish, and forests), there is still very little measurement of the effects that losing this natural capital will have on the economy and our environment.[6]

We have very little data that show the changes in our natural capital over time; and we haven't even identified and measured all the components of natural capital.

Wetland ecosystems help illustrate the type of goods and services natural capital provides. The list of goods and services shown in Table 2 includes water supply and treatment, food production, cultural benefits, habitat, disturbance regulation and total ecosystem values.

- Wetlands are essential components of watersheds and are critical for ecosystem maintenance. For example, small headwater wetlands and stream systems are the source of our freshwater. Therefore, changes that degrade these freshwater systems affect the health and productivity of streams, lakes and rivers downstream.[7]

- Wetlands are natural filters that improve water quality and help neutralize a number of different contaminants.[8] Wetlands remove nutrients such as phosphorus and nitrogen from water flowing into lakes, streams and rivers, as well as groundwater.[9] Wetlands can reduce nitrate and phosphorus up to 80 percent[10] and 94 percent[11] respectively.

- Excessive nutrients in water bodies lead to eutrophication (excessive algae production), which reduces oxygen content in the water to levels that kill fish and other creatures. Eutrophication also makes recreation unpleasant or impossible. High levels of nutrients such as nitrates make water unsafe for drinking.[12] Wetland plants such as duckweed can remove between 116 and 400 kg/ha/yr of phosphorus and 350 to 1,700 kg/ha/yr of nitrogen.[13] Other wetland plants have the capacity to remove or degrade toxic compounds such as heavy metals and pesticides.

- Wetlands recharge water supplies. Canada's rivers, lakes and streams originate from a myriad of small wetlands and streams and are critical for influencing the character and quality of downstream waters.[14] As well, wetland depressions are important in both groundwater recharge and water storage in many physiographic settings, including the northern glaciated prairies.[15] Each wetland may have a small storage, however collectively, storage is significant. For example, wetlands can store almost all of the snowmelt runoff generated in their respective watersheds.[16] Forest wetlands overlying permeable soil may release up to 100,000 gallons/acre/day into groundwater. Conversely, if the wetland is destroyed (drained, converted to another land use), ground water levels can be substantially reduced. For example, if 80 percent of a Florida cypress swamp were drained, the associated groundwater would be reduced by approximately 45 percent.[17]

- Wetlands help control floods by storing large amounts of water. Four-tenths of a hectare of wetlands can store over 6,000 cubic metres of floodwater.[18] Research in the Upper Mississippi and Missouri Basins showed that wetland restoration would provide enough floodwater storage to accommodate excess river flows associated with the 1993 flooding in the U.S. Midwest.[19] Conversely, when wetlands are destroyed, the probability of a given rainfall event causing flooding and floodwater damage increases significantly.[20]

- Wildlife viewing and photography is one of the fastest growing recreational activities in Canada. Many species make wetlands their homes, notably many bird species, amphibians, fish and mammals. Wetlands also provide for consumptive recreational activities such as fishing and hunting.

- Wetlands provide habitats for many plant and animal species. Approximately 600 species of wildlife, including species at risk, use wetlands in North America during some part of their life cycle.

- We use a wealth of products from wetlands including fish and shellfish, blueberries, cranberries, timber and wild rice, as well as medicines that are derived from wetland soils and plants. Commercial fisheries depend on wetlands for spawning and nurseries, and to provide food for growing stocks of fish and shellfish.

Valuing Natural Capital

Measuring the amount of natural capital is an essential first step in helping society make better decisions about land use and economic activity. Why then value natural capital and not just measure its quantity? First, one cannot sensibly 'add up' different types of natural capital in physical units. Twenty tonnes of forest biomass cannot be aggregated in a meaningful way with 20 hectares of wetlands or 100 litres of water purification provided by the wetlands. Monetary conversions help us add up 'apples and oranges'. Second, decision makers typically use monetary measures to compare land use options. For example, a 10-hectare housing project will generate so many dollars of property tax revenue each year. Having a value of the goods and services generated by the natural capital on that 10 hectares will allow the decision maker to compare these alternatives more easily and can help in formulating better regulatory policies.

Determining a value for natural capital can be very straightforward when the good or service has a market-determined value. There are many products derived from natural capital such as fish, timber and agricultural products, all of which have well-defined prices. However, for a great number of the goods and services natural capital provides, markets do not exist to help establish a price. Economists have come up with a number of techniques to help value these 'non-market' goods and services. The approaches fall into two main categories. Those that focus on economic damages – measurement of loss of incomes and output, reduced productivity, expenditures needed to offset loss of natural capital services and/or environmental damages (or, costs avoided if natural capital is preserved). The second is willingness of individuals to pay for goods and services from natural capital or willingness to accept compensation for the loss of natural capital as revealed through people's behaviour or upon direct questioning.

Table 3 lists the approaches taken and provides examples. All of these methods are imperfect in that they rely on specific case studies and sampled populations, and encounter difficulties in linking the measurement technique to the precise services provided by natural capital. That is why we present a range of estimates derived from different approaches and studies. Another problem is that there are very few valuation studies done for Canada. One often has to try to apply the values derived for one specific location to another. This process is called 'benefit transfer', and is the approach taken for some of the case studies discussed below. There is extensive literature discussing methodologies for valuing natural capital and the pitfalls encountered.[21] While some critics of valuation argue the techniques are so imperfect as to be worthless, others strongly disagree. To argue that we cannot value natural

capital implies that we assign a value of zero or infinite, neither of which are helpful for policy making. The estimates presented in the case studies rely mainly on market proxies or substitutes for the goods and services provided by natural capital. As such, they are less subject to criticism because they do not depend upon surveys of people's hypothetical willingness to pay. However, this means the values are likely to be lower bounds. Again, the intent is not to promote a specific valuation technique or actual dollar amount, but to illustrate that even these conservative estimates of the value of natural capital can be substantial. Ignoring the value of natural capital when making decisions about land use will likely result in degradation or destruction of natural capital and lead to outcomes that are very costly to society both now and into the future.

Examples of valuation studies are provided in Table 4. Two important conclusions can be drawn from these examples. Firstly, the value of sustaining natural areas can be substantial; and its corollary, the cost of finding substitutes for natural capital high. Secondly, there can be a wide range in the estimated values of natural capital goods and services. In the case studies highlighted below, we use a range of values to help frame the analysis.

right: Brian Wolitski

left, below right: Darin Langhorst

TABLE 3 – Valuation Methods for Benefit Estimation

Method	Environmental Application
Economic Damages from the Loss of Natural Capital or Costs Avoided by Preserving Natural Capital	
Changes in productivity	Health effects of pollution, loss of natural capital inputs into production, pollution impact on industries
Health care costs	Health effects of air and water pollution
Loss of capital	What people have to pay for the substitutes for natural capital goods and services, e.g., for sewage and water treatment, noise abatement, greenhouse gas absorption
Willingness-to-Pay Approaches	
Preventive/mitigating expenditures	Personal or community expenditures to offset noise, visual, air, water pollution effects
Hedonic estimation of property values	Valuing the impact on property values of proximity to natural capital (forests, water, wetlands). Negative impacts from higher levels of air pollution, noise, toxic wastes due to loss of natural capital
Travel cost	Recreational benefits of improved environmental quality as measured by expenditures to travel to nature sites
Contingent valuation	Asking people their willingness to pay for environmental quality – current and future, or willingness to accept compensation to avoid loss of natural capital goods and services

TABLE 4 – Examples of Valuation Studies

The Value of Products from Wetlands [22]

- Coastal wetlands provide life support for oysters valued at between $54 and $6,337 per acre per year in Virginia.
- Willingness to pay for fish and wildlife habitat by non-users in Alberta ranges from $267 to $453 per person per year.
- Willingness to pay for freshwater fishing in Lake St. Clair averages $97 per person per year.
- Willingness to pay for hunting and fishing in Alberta averages $400 per person per year.
- Willingness to pay for water quality improvement provided by riparian wetlands in the U.S. midwest ranges from $70 to $87 per person per year.
- The present value (over 50 years at a 6 percent discount rate) per acre of flood control provided by wetlands in Massachusetts is $96,010, while that of waste assimilation (nutrient filtering) is $75,196, and water supply services is $291,357.

Expenditures by British Columbians on Nature-Related Activities for the Year 1996 [23]

- Outdoor activities in natural areas = $1.5 billion
- Wildlife viewing = $302 million
- Recreational fishing = $329 million
- Hunting wildlife = $112 million

Value of Goods and Services from Canadian Forests [24]

- Market value of non-timber products (e.g., food, medicines, forage) = $.74 per hectare per year in British Columbia.
- Willingness to pay for recreational fishing is $3.17 per hectare per year, while that from hunting is $12.50 per hectare per year, as estimated by contingent valuation studies.
- Canadians are willing to pay $57.65 per hectare per year to view wildlife, and $44.64 per hectare per year for recreational activities such as camping, hiking, and kayaking as estimated by contingent valuation studies.
- Carbon sequestered by forest biomass and soils ranges from $15 to over $600 per hectare per year.

Agricultural Lands [25]

- Net income from farm production in British Columbia averaged $164 per hectare per year over the period 1997-2001.
- Preservation and scenic values provided by agricultural land ranges from $1.33 to $2.42 per household per year.
- Canadian farms could save between .94 and 1.9 tonnes of greenhouse gases per year if more conservation-oriented farming practices were adopted. This would generate savings if the emissions were not released of between $5.48 and $34.34 per hectare per year in Saskatchewan, or $10.45 to $32.94 per hectare per year in Ontario.

Note: All values are in 2003 Canadian dollars.

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case studies: illustrating the value of natural capital

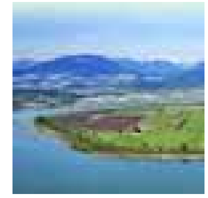
right: B. Stanley

The following case studies were assembled to illustrate that the preservation or restoration of natural areas within the settled areas of Canada will create substantial net benefits to society. The first case study illustrates the threats to the lower Fraser Valley of British Columbia – an area rich in natural capital that is facing massive pressure from urbanization and industrialization of agriculture that is destroying and degrading natural areas.[26] Valuing the natural capital from the Fraser Valley could help improve land use planning and save British Columbians millions of dollars in avoiding the construction of costly substitutes for the services of natural capital and the loss of these valuable goods and services. Three additional case studies show that the preservation and restoration of natural areas within agricultural landscapes can create substantial net benefits to society and support the new Agricultural Policy Framework (APF) of Canada.

The Lower Fraser Valley Case Study

The Lower Fraser Valley encompasses approximately 16,225 km^2 and contains some of Canada's best agricultural land, sensitive wetlands, forests and other natural areas. It is home to about 57 percent of the population of British Columbia. The Lower Fraser Valley encompasses two jurisdictions: the Greater Vancouver Regional District (GVRD) and the Fraser Valley Regional District (FVRD).

Lower Fraser Valley



Major Threats to Natural Capital in the Lower Fraser Valley

- Construction of low-density suburban housing that uses large amounts of land
- Loss of forests, wetlands and riparian habitat to urbanization, diking and industrial agriculture
- Runoff from urban centres, agricultural lands and sewage treatment plants increase the amount of nutrients, sediments and toxic compounds in surface and groundwater
- Air and water pollution from urban growth and industrial agriculture

Much natural capital in the watershed has already been degraded or destroyed by the growth of cities and industrial agriculture in the region.

> "That there is pressure on the land, competition between land users and degradation of the natural environment is all too plain. Less evident is the burden that all this growth and the particular lifestyles of the inhabitants places on the stock of natural resources – the demand for water, energy, leisure and recreation, food and industrial production. The 'withdrawals' from the ecosystem have been growing alarmingly, but so too have the 'additions'… The land, the air, the rivers, the lakes and the Strait of Georgia are called upon to absorb more and more wastes generated by households, agriculture and industry." [27]

Threats from Urbanization

With an annual growth rate of 2.6 percent between 1990 and 2000 – a figure higher than megacities such as Cairo, Jakarta and Rio de Janeiro, Greater Vancouver has experienced significant population increases, from 1.8 million in 1996 to almost 2 million inhabitants in just five years.[28] A recent report estimates that the average annual population growth over the coming years to 2020 will be approximately 1.7 percent for the GVRD and 2.4 percent for the FVRD. If this occurs, the population will total over 3 million by 2020.[29]

If, over time, existing urban areas increase their density by just over 6 inhabitants per hectare rather than extend development to natural areas in the Fraser Valley, the expected population growth will not require further consumption of agricultural, forested and other natural areas.[30] However, given the existing patterns of urbanization, current public policies and lack of incentives to private landowners and public officials to incorporate the values of natural capital into their decision making, it is more likely that existing natural areas will be converted to suburbs and commercial service areas. In Canada, the number of people living in low-density neighbourhoods of single family detached houses has risen dramatically since the Second World War. By 1970, more Canadians were living in suburbs than in either the countryside or the central city.[31] In Greater Vancouver in 1971, suburbs dominated by single family homes accounted for 61 percent of its population. By 1996, 72 percent of Greater Vancouver's population resided in its suburbs.[32] Recent data indicate for every 1,000 new inhabitants in Vancouver, 28 hectares of land are urbanized because of low-density growth.[33] At current population growth rates, 28,000 hectares of land will be consumed by 2026, 17 percent of what

remains of GVRD's total non-developed land-base, and 28 percent of what remains of the GVRD's non-urbanized land base on the Fraser Valley floor.[34]

Land-intensive single-family homes constituted 41 percent of housing completions in the region in 2001, the highest in five years. Less than half of the population growth between 1996 and 2001 occurred in the extended metropolitan core of Vancouver, Burnaby, New-Westminster, Coquitlam, Port Coquitlam and Port Moody. The remainder of this growth occurred mostly in the suburban municipalities of Langley, Surrey, Richmond, Maple Ridge and Pitt Meadows.

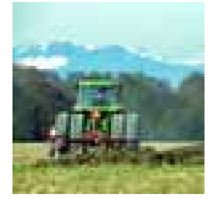
Municipalities will likely pursue further sprawling development. One of the reasons for this is that property taxes make up almost 52 percent of municipal revenues in British Columbia in 2000, a figure that has risen in recent years.[35] High property taxes in dense urban cores drive away artisans, families and small stores, who relocate in suburbs where property taxes are lower. Suburban communities, because they equally rely on property taxes, encourage this urban emigration, and accommodate development and construction of new homes with a variety of policies that encourage conversion of natural areas to suburban housing developments and commercial use.[36] Other factors encouraging sprawling development include government policies such as those related to road construction, funding of sewer and water infrastructure servicing new suburban communities, and subsidized public transportation that encourage development of suburban areas.

Urban and industrial development not only alters land use, but also creates significant environmental stress in the form of air and water pollution.

Urban and industrial development not only alters land use, but also creates significant environmental stress in the form of air and water pollution. Non-point urban effluents occur mostly from urban runoff that finds its way into waterways through storm drains. These waters are laced with contaminants including lead, zinc, hydrocarbons and other sediments, and account for a significant portion of suspended solids loading in the lower Fraser River and Burrard Inlet.[37] Although storm water is connected with sewer mains in Vancouver and thus treated under normal conditions, when there is heavy rain, sewer flows exceed treatment plant capacity that results in spills of raw and untreated sewage directly into waterways. Approximately 25 tons of organic material enters the Fraser River from sewage treatment plants daily and roughly an equivalent amount of pollution is discharged from industrial sources.[38] Point sources of water pollution come predominately from municipal wastewater treatment plants (70 percent of the effluent into Vancouver's waterways), the balance from industrial sources. While sewage wastes are typically diluted enough by the flow of the Fraser River to meet guidelines for industrial and irrigation uses, the water quality is below that safe for drinking or direct-contact recreation.

left: Brian Wolitski below, right: B. Stanley

Loss of Natural Capital in the Fraser Valley



The loss of natural capital is seen in many dimensions. Historically, floodwaters brought nutrient-rich silt to the valley floor and rejuvenated its wetlands each spring. Now wetlands have been drained, and much of the land lies behind 600 kilometres of dikes. The dikes significantly altered the hydrology of the Fraser River Valley, cutting the river off from some of its tributaries and flood plain, changing runoff patterns and fish habitat. Approximately 70 percent of the river margin wetlands had been diked off from the river by the late 1970s. Their main purpose is flood control, but experts have predicted a one-in-three chance within the next 60 years of a “flood of record” event, which would breach or over-top many of the dikes, resulting in catastrophic damage.[39] Had more of the natural capital of the Lower Fraser Valley’s wetlands been preserved, the region would have both natural and physical capital to help absorb the many centimetres of precipitation received each year, while simultaneously preserving the many other benefits from the natural capital.[40]

Much of the valley floor used to be forested, but by 1990, most of the forests and wetlands in the lowlands were gone, replaced largely by agricultural and urban land. Extensive forests remain only in the mountains. Dozens of streams once crisscrossed the lands. Of the 779 assessed streams in the Lower Fraser Valley, 15 percent have been completely lost, and another 72 percent are threatened or endangered. Only 106 streams (14 percent) are in good condition and able to recover.[41] Only Musqueam Creek remains within the city as a salmon-bearing stream. From the late 1980s to late 1990s, almost 1,000 hectares of wetlands were lost in the Lower Fraser Valley. The Fraser lowlands now have the second-highest number of species at risk in B.C. Less than five percent of this ecosystem is currently protected under the province’s Protected Areas Strategy.[42] The Fraser River estuary is a crucial staging area on the Pacific flyway for millions of migratory birds and supports the highest density of water birds and raptors in Canada. The Fraser River estuary provides feeding and roosting sites to about 1 million migrating and wintering waterfowl and 5 million shorebirds. Key species include trumpeter swans, lesser snow geese, Pacific brant, northern pintail, American wigeon, dunlin and western sandpipers. Loss of wetland habitat and increased industrialization of agriculture threaten these species. These impacts reduce the amount of available wildlife habitat and food sources, provide additional disturbances through increased human activity and habitat fragmentation and concentrate wildlife on the remaining habitat patches thereby increasing mortality.

Threats to and from Agriculture

The Lower Fraser Valley has been one of the most productive agricultural regions in Canada. Agricultural land in the GVRD and FVRD produced output valued at almost $1.4 billion in 2001, yielding an average of $16,887 per hectare of agricultural land.[43] Agricultural land is both under threat and a source of degradation of natural capital. From 1961 to 1991, agricultural land in the Lower Fraser Valley declined by 23 percent and declined a further 4 percent from 1991 to 2001 (from 111,120 to 85,825 to 82,361 hectares). The introduction of the Agricultural Land Reserve (ALR) in 1973 with its protection of lands favourable to agriculture slowed the rate of decline from what it had been from the 1960s to 1970s, but has not stopped the conversion of agricultural land to urban development.[44] However, in comparison to other regions, the ALR represents a very successful policy. A recent study comparing growth patterns of Seattle, Washington and Vancouver[45] emphasized the success of the ALR in deterring urban sprawl, showing that the ALR obliged local governments to require development in existing urbanized areas (densification) rather than convert natural lands to housing and commercial uses. Had greater Vancouver sprawled like Seattle during the 1990s, it would have developed an additional 18,000 acres – an area approximately four-fifths the size of Burnaby to accommodate residential growth. And if greater Vancouver had the same overall population density as Seattle, an additional 650 km^2 of land would be covered with suburban development, which is equivalent to all of the remaining developable land in the regional district, plus four-fifths of the remaining agricultural land.

A potentially more serious threat to natural capital comes not from the loss of agricultural land, but from wastes from the 'industrialization' of agricultural lands without a corresponding increase in the treatment or containment of waste products from agriculture. Agricultural industrialization of the Lower Fraser Valley occurs in at least three ways: greater use of fertilizers and pesticides per hectare, an increase in livestock densities, and the conversion of crop land to greenhouse production. Commercial fertilizer use increased 164 percent between 1971 and 1991, and spraying and dusting rose significantly.[46] Changes from higher nitrogen uptake crops such as forage to lower uptake crops such as raspberries has also led to greater nutrient loading of the environment.

left: Brian Wolitski right: B. Stanley

In the period from 1986 to 1991, the stock of pigs and chickens rose by approximately 50 percent (pigs from 24,947 to 37,540, chickens from 285,918 to 496,428).[47] The average number of livestock per hectare was estimated in the mid-1990s to be above the maximum carrying capacity estimated for the land.[48] This leads to animal waste being applied to the land in excess of the ability of the environment to absorb and neutralize these nutrients.

Runoff of agricultural waste products is recognized as the prime contributor to the degradation of ground and surface waters in the Fraser Valley.[49] Wetlands and riparian areas adjacent to streams, because of the role they play in filtering these effluents, become increasingly important in maintaining a healthy aquatic ecosystem. The excess manure, in conjunction with the application of chemical fertilizers, has resulted in excessive nutrient loads on substantial areas of farmland in the study area, leading to nutrient-laden runoff into water systems and unbalanced soil conditions. An average of 273 kg of nitrogen, 84 kg of phosphorus and 165 kg of potassium were applied per hectare per year on farms in the Fraser Valley, well above and sometimes twice what was needed for the most nutrient-intensive crops.[50] Of the total nitrogen, 17 to 48 percent found its way into drainage ditches and thus surface water systems.[51] Excess nutrients that are not absorbed into the water system interact with soil to slow organic decomposition and destabilize nutrient and pH levels, leading to acidity problems. Acidity problems in the study area are affecting more of the Valley's land over time.

Agricultural industrialization of the Lower Fraser Valley occurs in at least three ways: greater use of fertilizers and pesticides per hectare, an increase in livestock densities, and the conversion of crop land to greenhouse production.

Nitrate levels in water, while generally below the limit considered unsafe in streams draining agricultural lands in the region, are becoming an increasing concern in the groundwater of the Fraser Valley. For example, nitrate levels in half of all well samples of the Abbotsford aquifer were higher than the safe limit. The groundwater in both Abbotsford and Langley also contains inorganic chemicals (from herbicides, pesticides and fumigants) in concentrations sufficient to cause concern. "The principle causes of this pollution are inadequate agricultural practices and badly constructed or maintained septic tanks." [52]

Between 1998 and 1999, the delta and farmlands around Boundary Bay and Roberts Bank experienced a 58 percent growth in glass greenhouses, and a significant reduction in available feeding grounds for ducks, shorebirds and geese using the area. Coupled with the increase in extent of glass is an increase in the number and size of buildings and storage areas required to service the greenhouses. Greenhouses are generally built adjacent to a dike to take advantage of the moderating effects of the ocean on temperature to reduce heating costs. This may impede the daily movements of migratory waterfowl and shorebirds between the intertidal habitats and agricultural lands. In 1999, greenhouses encased 1.4 percent of the delta's agricultural land; five large-scale greenhouses were being planned for the area and others possibly to follow. In 2001, the cities of Surrey and Delta had 153 hectares of greenhouses, up from 55.5 hectares in 1996, an increase of 176 percent.[53]

Valuing the Lower Fraser Valley's Natural Capital

Table 5 shows recent land uses in the floodplain portion of the GVRD and FVRD. If pressures to 'suburbanize' the natural lands within the basin continues without a change in public policy and creation of incentives for private land owners to incorporate the value of nature in their land use decisions, British Columbians will lose many goods and services from their natural capital. They will then either have to replace them at considerable cost or forego them completely. Illustrations of the value of natural capital goods and services from the region's natural areas highlight the value of preserving nature and the costs of its destruction or degradation.

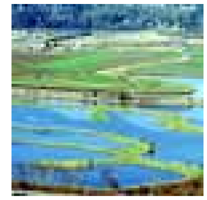


Table 5 shows that natural areas comprise a significant share of the land. These can constitute wetlands, lakes, rivers and streams, the riparian lands surrounding them, estuaries, and so on. A further breakdown of natural area is not possible because the Lower Fraser Valley lacks accurate documentation of existing land uses, let alone any sort of estimates of the changes in land use over time. Environment Canada produced a detailed inventory of land uses for the period between 1980 and 1987. That survey found that 644 hectares of land in the Lower Fraser Valley were converted to urban land each year. We do not have a good estimate of what has been lost over the past 17 years. The estimates below are thus only illustrative.

TABLE 5 – Land Use (hectares) in the Lower Fraser Valley

Land Use Catagory	GVRD	FVRD	Study Area Total
Agricultural	37,064	45,296	82,361
Urban	75,000	12,978	87,978
Forest*		4,368	
Natural Areas			
Open & Undeveloped	43,440		
Protected Watershed	46,880		
Recreation & Protected Natural Areas	63,880		
Residential - rural	11,150		
Park		12,197	
Resource		7,397	
Rural		9,383	
Other		6,544	
First Nations Reserve		2,514	
Limited Use		3,074	
Total Natural Areas	165,350	41,109	206,459
Total: All Categories	**277,414**	**103,751**	**376,798**

GRVD and FVRD total wetlands = 42,000 ha.

** Forest land estimates are included in the categories of natural areas and not identified separately for the GVRD.*

Sources and dates: *GVRD data is for 2001 and from communication with the GVRD and Ministry of Community Aboriginal and Women's Services. FVRD data for agriculture is from the 2001 Census; for urban from the FVRD Planning Department,* Choices for our Future: Planning for Urban Growth Boundaries in the Fraser Valley, *1999. Forest and natural areas data is from the FVRD, Phase 1, Technical Report: A Technical Report Outlining the Future Distribution of Population, Homes and Jobs in the Fraser Valley, 1998. Wetlands data is for 1992 and compiled under the Wetlands Inventory. http://www.bcwetlands.com/new/frasletters/Wetnet?news/95_03/fraser-valley.htm*

Goods and Services from Wetlands

Wetlands absorb considerable amounts of nitrogen and phosphorus and can serve as a natural waste treatment plant for the excessive amounts of these fertilizers leaching from farms into the Fraser Valley's water bodies.[54] Estimates of the savings in waste treatment costs provided by nature likely underestimate the value of the wetlands as a waste treatment facility because they do not reflect society's total willingness to pay for water quality. The costs of removing phosphorus vary from $21.85 to $61.20 per kilogram at Vancouver's primary

left, right: DU Canada

and secondary waste treatment plants, while costs for nitrogen vary from $3.04 to $8.50 per kilogram.[55] It is not known exactly how much phosphorus and nitrogen a typical wetland can absorb because amounts depend on the particular type of wetland, its location and plant composition, and the chemical and physical characteristics of soil type.[56] Some estimates from the literature are that wetland plants (duckweed and pennywort) can remove between 116 and 770 kg/ha/yr of phosphorus and 350 to 32,000 kg/ha/yr of nitrogen.[57] A quasi-natural field of reeds can remove 101 kg/ha/yr of phosphorus and 1,910 kg/ha/yr of nitrogen.[58] Estimates from a North American database offer the conservative estimates of 80.3 kg/ha/yr for phosphorus, and 547.5 kg/ha/yr for nitrogen.[59] While these estimates have a wide range, even the most conservative estimate exceeds the amount of excess nitrogen and phosphorus that finds its way into the region's water supplies from current agricultural practices.[60]

The annual value of waste treatment of phosphorus and nitrogen produced by one hectare of the Fraser Valley's wetlands is estimated to be at least $452 and may be as high as $1,270. The annual nitrogen and phosphorus waste treatment benefits received from the existing 40,000 hectares of wetlands in the Lower Fraser Valley's wetlands could thus amount to between $18 and $50 million per year.[61]

These waste treatment services are a small part of the total value of a wetland to the region. A number of studies have put the annual value of all the goods and services generated by one hectare of wetlands (fish, shellfish, waterfowl, mammal and reptile habitat; water supply; erosion, wind, wave barrier; storm and flood control; and recreational opportunities) at between $5,792 and $24,330.[62] If the approximately 40,000 hectares of Lower Fraser Valley wetlands were valued at the lowest estimate, its annual value would be $231.7 million. This is clearly an overestimate because not all of the wetlands provide each good and service indicated. Two studies provide a bit of additional perspective. The ecological services from 1,890 hectares of the Burns Bog in the Fraser Valley were estimated at approximately $60 million per year or $31,375 ha/yr.[63] A study of flood protection benefits alone for wetlands in the Seattle area found values ranging from $408 to $2,110 ha/yr.[64]

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Goods and Services from Forest Lands

The Lower Fraser Valley has an estimated 6,132 hectares of forests in the floodplain area. These forests, if uncut, provide some small amount of food harvest (berries, mushrooms), fishing and hunting terrain, wildlife viewing, other forms of recreation such as camping and hiking and carbon sequestration. Using estimates for temperate coniferous forests, the annual value of these goods and services from the forest is $134/ha/yr, excluding the carbon sequestration services.[65] Thus, a lower bound estimate of the Fraser Valley's forests in the floodplain yield over $824,000 worth of goods and services per year if uncut. This number does not reflect the other services provided by forests such as erosion control, water storage and purification. Carbon sequestration is not an annual benefit, because it reflects the total amount of carbon stored per hectare. This estimate ranges from $150 to $6,080 per hectare, and can be converted to an annual benefit by assuming the forest is sustained indefinitely. At a discount rate of 10 percent, the annual benefits are $15 to $608/ha/yr.

Recreational Benefits from Natural Areas

Recreational services can be in the form of wildlife viewing, hunting and fishing, camping and swimming, hiking and skiing. No comprehensive study has been done to estimate the recreational benefits of the region. Using a survey done by Environment Canada[66] for British Columbia, a very rough estimate of the values can be placed on some of the recreational services provided by the Fraser River Valley. The region may provide $53.45/ha/yr per year in benefits from wildlife viewing and $36.40/ha/yr in benefits from hunting and fishing. If all natural land in the region generates these benefits, the total would be approximately $19 million per year. This estimate probably significantly underestimates the annual benefits as it does not capture the other recreational uses of the valley's natural capital.

Ecological Services from Agricultural Lands

Properly valuing the net social benefits from agricultural lands involves a very complex computation of the value of the agricultural products derived, net of production costs and the value of the waste byproducts that must be treated by physical capital or the natural environment. These sorts of calculations have not been done for the Fraser Valley, but are the focus of the next three case studies.

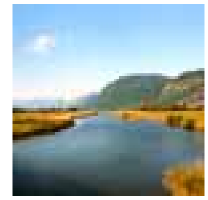
Goods and Services from Natural Areas

One estimate[67] of the ecosystem values of natural areas provides some numbers for the land uses we are not able to identify individually. Each hectare of an estuary may annually be worth $22,832; lakes and rivers – $8,498; temperate/boreal forests – $2,007; and grass/rangelands – $232. These numbers are not for any specific country or region, but represent the value of the net primary production of each ecosystem. While these numbers are highly speculative, they serve as a reminder of the potential value of lost production if ecosystems are destroyed or degraded. The Lower Fraser Valley ecosystem epitomizes one where protecting nature may save society hundreds of millions, if not billions of dollars every year.

Table 6 summarizes the values per hectare that may be obtained from components of the natural capital in the Lower Fraser Valley. The estimates should be viewed as examples. While they cannot be aggregated because they come from a number of different studies and hence some measure the same goods and services, they clearly illustrate that each hectare of land in the Fraser River Basin can generate substantial values if the natural capital is protected.

TABLE 6 – The Current Value (per hectare per year) of Conserving Natural Capital in the Lower Fraser Valley

Type of good or service	High	Low	Single Estimate
Waste treatment services – removal of nitrogen and phosphorus	$ 1,270	$ 452	
All goods and services provided by wetlands	$ 24,330	$ 5,792	
Flood protection from wetlands	$ 2,110	$ 408	
Forests: food harvests, recreational uses			$ 134
Carbon sequestration from forests	$ 608	$ 15	
Wildlife viewing			$ 53
Hunting and fishing			$ 36
Goods and services: Estuaries			$ 22,800
Goods and services: Lakes and rivers			$ 8,500
Goods and services: Temperal/boreal forest			$ 2,000
Goods and services: Grasslands and rangelands			$ 230



The Lower Fraser Valley ecosystem epitomizes one where protecting nature may save society hundreds of millions, if not billions of dollars every year.

Agricultural Case Studies[68]

left: Darin Langhorst right: Andrew McLachlan far right: DU Canada

Canadian agriculture has adopted increasingly intensive management practices over the past 50-75 years. Pressures to compete internationally, large capital costs for the increasing mechanization and industrial farming, high levels of debt and uncertain crop prices make it difficult for farmers to focus on long-term sustainability of their agricultural lands. To sustain their livelihoods, farmers must focus on their private net returns from food production. As Table 2 notes, agricultural lands also produce ecosystem benefits to society. But because farmers typically receive no payment for the ecosystem benefits generated by their lands and farming techniques, they have little incentive or ability to protect nature. In addition, there is often poor understanding of how changes in farm management might increase natural capital while also providing private benefits to the farm. An example would be allowing natural areas to persist and provide habitat for pollinators, predators for pest species, or water retention.

When the value of natural capital on a portion of land exceeds the value of that land used for agriculture, it would be economically efficient to convert that land to some form of permanent vegetative cover (also known as conservation cover) that is no longer used for agricultural purposes. Additionally, agricultural practices could be altered to minimize and mitigate land degradation and enhance the natural capital on farm lands as is proposed through various beneficial management practices (BMPs) under the new Agricultural Policy Framework.

Permanent vegetative cover and ecologically sound farming practices can help to:

- Improve water quality and decrease water treatment costs;
- Lower dredging costs to remove sediment from water conveyance and storage infrastructure;
- Increase recreational opportunities such as fishing, swimming, hunting and wildlife viewing;
- Decrease net greenhouse gas (GHG) emissions;
- Mitigate flooding; and
- Protect and enhance ecological services.

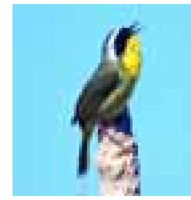
This section highlights three case studies from different agricultural regions of Canada. The cases present the threats to natural capital in each region, provide estimates of the value of natural capital, and illustrate that there are cases where it might be in society's interest to change farming practices to protect natural areas. The cases also repeatedly show that we lack good data measuring the physical amount of natural capital; where these fundamental data are a prerequisite for estimating the value of conserving natural capital and are needed to help make informed public policies about land use.

The Grand River Watershed

The Grand River watershed is the largest in southern Ontario covering approximately 6,800 km^2, running from Dundalk in the north to Lake Erie in the south. Of this total area, more than 75 percent of the watershed is agricultural land. The cities of Guelph, Kitchener, Waterloo, Cambridge and Brantford are within the watershed with a total watershed population of 875,000 in 2003, and a forecasted population of over 900,000 by 2021. These urban areas depend on surface and ground water resources. The Grand River watershed is illustrative of the types and values of natural capital that could be obtained from agricultural lands in watersheds of southern Ontario.

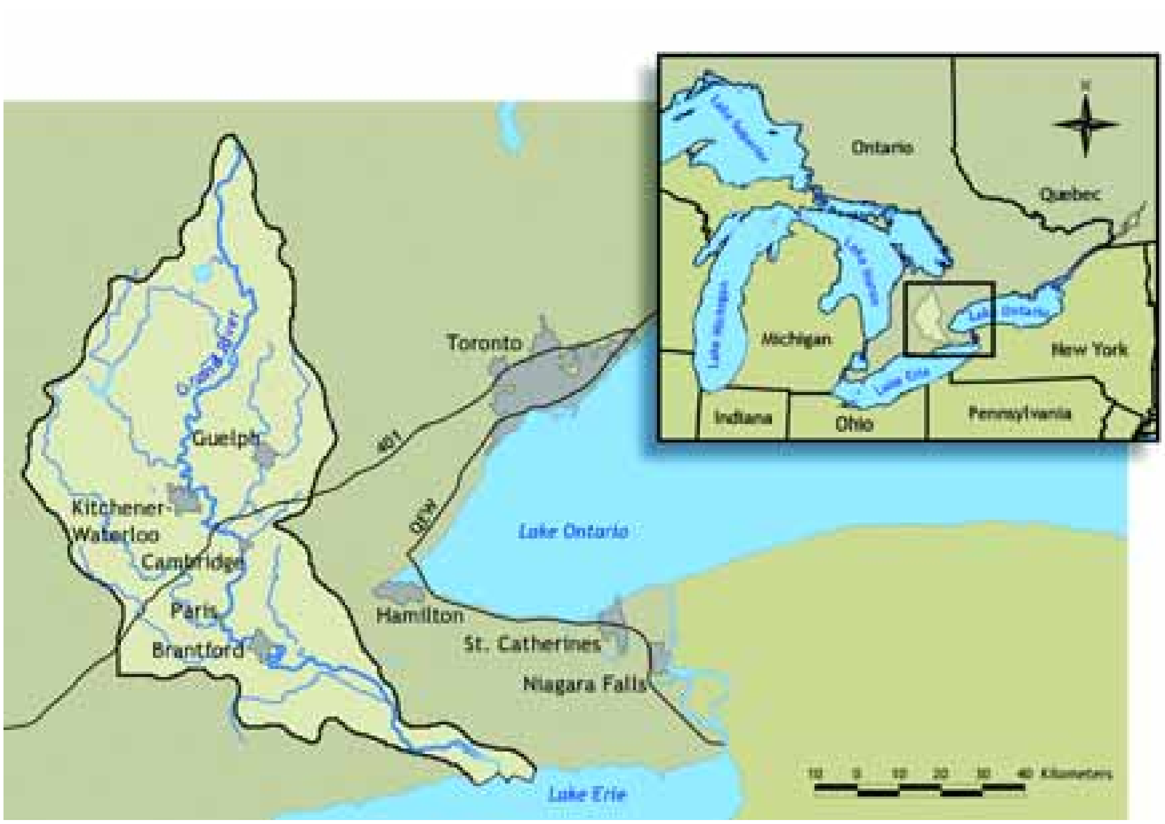
The Grand River watershed is illustrative of the types and values of natural capital that could be obtained from agricultural lands in watersheds of southern Ontario.

Twenty-six sewage treatment plants which service approximately 680,000 people discharge treated wastewater into the Grand River. The cumulative pressures on the river from municipal sewage treatment plants and the growing agricultural industry in the watershed question the future capacity of the watershed to assimilate wastewater.



Rates of soil erosion decrease with increased levels of vegetative cover. Vegetation along rivers and streams also purifies the water by filtering out fertilizers, animal waste, pesticides and herbicides. Rates of erosion and the delivery of sediment and nutrients (e.g., phosphorus) into rivers and streams vary by soil texture, slope and the cropping practices in place. Farming practices that enhance vegetative cover can reduce sediment erosion from over 6 tonnes to less than one tonne/ha/yr. Sediment delivery would fall from approximately 0.6tonne/ha/yr to 0.15tonne/ha/yr or less, and phosphorus delivery would be cut by approximately 70 percent. Society then saves water treatment costs, as was illustrated by the Fraser River Basin case.

Sediment from soil erosion also becomes deposited in roadside ditches and other conveyance structures and reduces the capacity of reservoirs and storage facilities within the watershed. This impact can reduce the effectiveness of these structures and increase the likelihood of flood events.



Grand River Watershed

left: Andrew McLachlan right: Darin Langhorst below right: Dave Kostersky

Major Threats to Natural Capital in the Grand River Watershed

- Runoff from urban growth, agricultural lands and sewage treatment plants contribute to nutrients and sediments in the Grand River[69]
- Soil erosion and sedimentation reduce water quality, increase costs of water treatment, and reduce recreation uses in the watershed
- Loss of wetlands and riparian habitat to agricultural use

The Grand River is considered a world class fishery with some upper tributaries providing high-quality trout fishing. Sediment harms fish in lakes and streams by damaging spawning and feeding areas and by reducing respiratory efficiency. Permanent vegetative cover in riparian areas would help increase the productivity of streams for high value fish, such as trout, because it reduces water temperature. Canoeing, kayaking, swimming and camping are other recreational activities whose enjoyment may be enhanced by increased water quality and better scenic amenities along the banks of the rivers and streams where riparian vegetation exists. Perennial vegetative cover also increases wildlife habitat compared to land that is annually cropped. Both hunters and wildlife viewers benefit from increased wildlife populations and diversity.

The Net Benefits of Protecting Natural Areas or Converting Tilled Lands to Natural Areas

Table 7 summarizes high, low and 'best' estimates for the net value of protecting natural areas in the Grand River Watershed. The Appendix (p. 27) shows in more detail how Belcher et al. derived these values for this case and the two that follow. The net benefits are significant, even at the low estimate. To provide perspective, these net benefits of conserving natural areas can be compared to the market value of the land in the watershed. Belcher et al. estimate a land supply curve using available information on land rental rates and prices for the crops grown in the region. This information can be compared to the estimates of the value of natural capital. Average rental rates for agricultural land in the Grand River watershed range from approximately $74/ha to $247.10/ha.[70] The estimates of the net benefits from conserving natural capital fall into the same range with the high estimate exceeding the high market value. It would be in society's interest to find policies that will help conserve the natural capital on the agricultural lands generating the highest net benefits to conservation.

TABLE 7 – The Net Value of Conserving Natural Capital in the Grand River Watershed[71]

Benefits (costs) $/hectare/year	High	Best Estimate	Low
Saved government payments[72]	69.98	46.45	23.23
Water Treatment: sediment reduction	10.27	5.60	1.87
Water Treatment: phosphorus reduction	44.50	23.50	2.50
Decreased sedimentation of conveyance/storage	1.27	0.69	0.23
Decreased flooding	7.50	4.80	2.10
Increased recreational fishing	48.44	26.42	8.81
Other river-based recreation	2.80	1.40	0.70
Reduction in GHG emissions	28.80	19.20	9.60
Carbon sequestration	26.85	17.90	8.95
Increased wildlife hunting	35.04	17.52	8.76
Increased wildlife viewing	68.97	34.49	17.24
Gross benefits	**344.12**	**197.97**	**83.99**
Program administration costs	(1.04)	(2.08)	(3.12)
Wildlife depredation compensation	(0.32)	(0.64)	(0.96)
Net benefits	**342.76**	**195.25**	**79.91**

The Upper Assiniboine River Basin

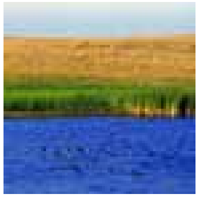
The Upper Assiniboine River Basin (UARB) is a region dependent predominately on agriculture. The UARB consists of 21,000 km^2 in east-central Saskatchewan and western Manitoba. There are 1,024,814 cultivated hectares on 5,800 farms. Of the 60,000 people who live in the basin, 30 percent are considered rural residents. The basin affects more than those residing in its boundaries. Residents of downstream communities including Brandon and Portage la Prairie get their drinking water from the Assiniboine River. The basin is hummocky in the southern portion with an abundance of streams and tributaries. Seventy percent of the soils are considered highly productive. Annual crops are the leading agricultural output, followed by livestock and forage production.

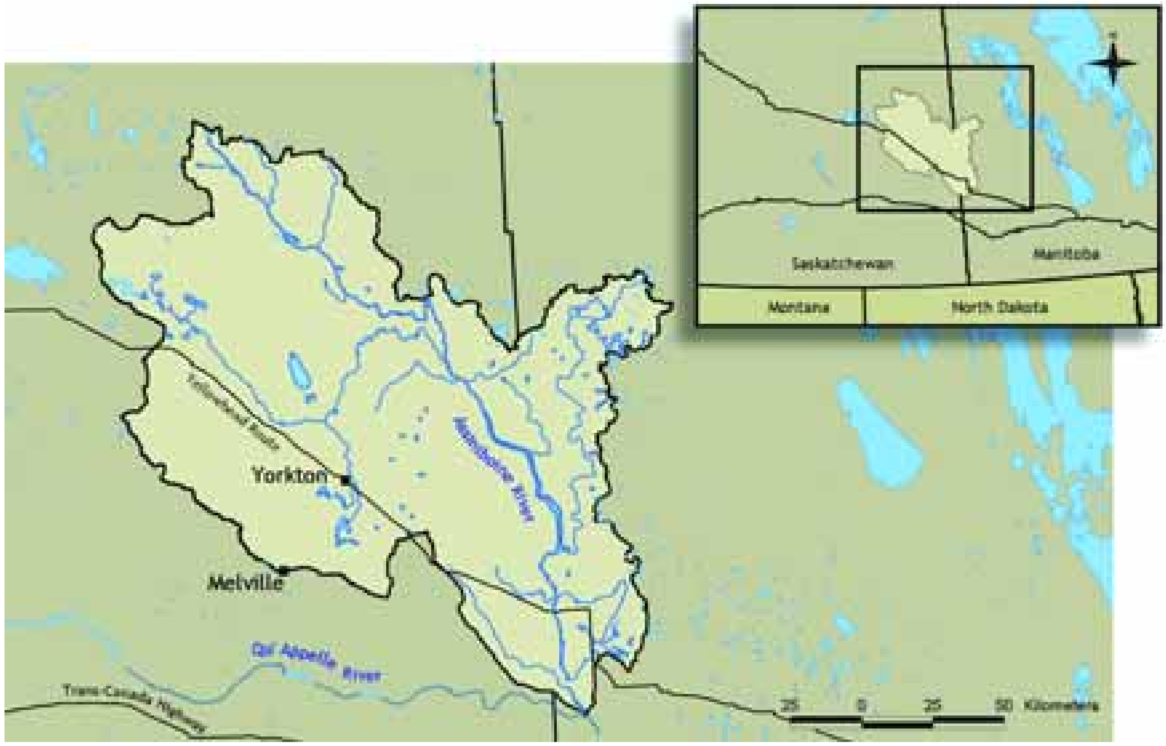
Major Threats to Natural Capital in the Upper Assiniboine River Basin

- Loss of wetlands and riparian habitat to agricultural use
- Increased danger of flooding due to loss of wetlands
- Soil erosion from agricultural production leading to increased sedimentation of surface waters and wind-blown soil contributing to respiratory health effects and loss of visibility
- Increasing concern about decline in water quality due to increased livestock densities

Over the past century, the land in the basin was cleared of trees and vegetative cover, and wetlands were drained. The impact of this land conversion on hydrologic characteristics of the region has been a major concern. In the late 1990s, following a major flood in 1995, a study was undertaken of water resource issues such as drainage and flood control, and the degradation of valuable wetland habitat.[73]

Erosion rates for the black soil zone of Saskatchewan are highly variable in this landscape, depending on soil texture, slope and cropping practices in place. Sites in both the Saskatchewan and Manitoba portions of the basin have been monitored for water quality. On average, most of the indicators were within the water quality objectives set by the provinces. While water supplies in the basin are adequate for consumption and production, projected





left: Darin Langhorst right: Brian Wolitski

Upper Assiniboine River Basin

increases in livestock numbers and density may begin to have a bigger effect on water quality. As indicated in the Lower Fraser Valley case study, increasing livestock densities may lead to excessive nitrates and other compounds contaminating water supplies, further increasing the benefits of converting land to wetlands and other natural areas.

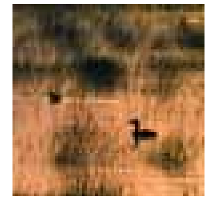
Wind erosion is a problem in the basin. Blowing soil increases the costs of cleaning and maintenance for businesses and households, damages non-farm machinery, and adversely affects health (especially children, the elderly and those with lung disease).

The Net Benefits of Protecting Natural Areas or Converting Tilled Lands to Natural Areas

Table 8 presents high, low and 'best' estimates of the benefits and costs of protecting a natural area or converting a hectare of agricultural land to permanent vegetative cover that does not deplete the natural capital on that land.[74] Market lease rates for agricultural land comparable to that in the river basin range from approximately $28 to $52 per hectare. Table 8 shows that the low estimates of the net benefits from conserving natural capital are of the same order of magnitude as the low lease rates, while the high estimates are considerably above the high lease rates. Conserving natural capital could thus provide society with larger benefits than agricultural production on a portion of the lands within the river basin. For example, if the net benefits of conserving natural capital are approximately $33 per hectare, 22,000 hectares of land with lease rates below $33 could be conserved, yielding a net return to society of $750,000 per year.

TABLE 8 – The Net Value of Conserving Natural Capital in the Upper Assiniboine River Basin [75]

Benefits (costs) $/hectare/year	High	Best Estimate	Low
Saved government payments	19.25	12.83	6.42
Saved crop insurance premiums	5.27	3.51	1.76
Improved water quality - decreased sediment	9.34	4.62	1.34
Water-based recreation	1.37	0.91	0.46
Reduced wind erosion	4.01	2.67	1.34
Reduction in GHG emissions	14.07	9.38	4.69
Carbon sequestration	29.40	19.60	9.80
Increased wildlife hunting	19.11	10.71	5.36
Increased wildlife viewing	6.45	4.16	2.08
Gross benefits	**108.25**	**68.39**	**33.23**
Program administration costs	(1.04)	(2.08)	(3.12)
Wildlife depredation compensation	(0.32)	(0.64)	(0.96)
Net benefits	**106.89**	**65.67**	**29.15**



The Mill River Watershed

The Mill River watershed is located in western Prince Edward Island and drains into Cascumpec Bay, a large, generally shallow estuary. The watershed encompasses 11,270 hectares of which 3.4 percent is wetland, 43.2 percent is agriculture, 46.0 percent is forest and 7.4 percent urban development. Shell and fin fishing are key activities. [76]

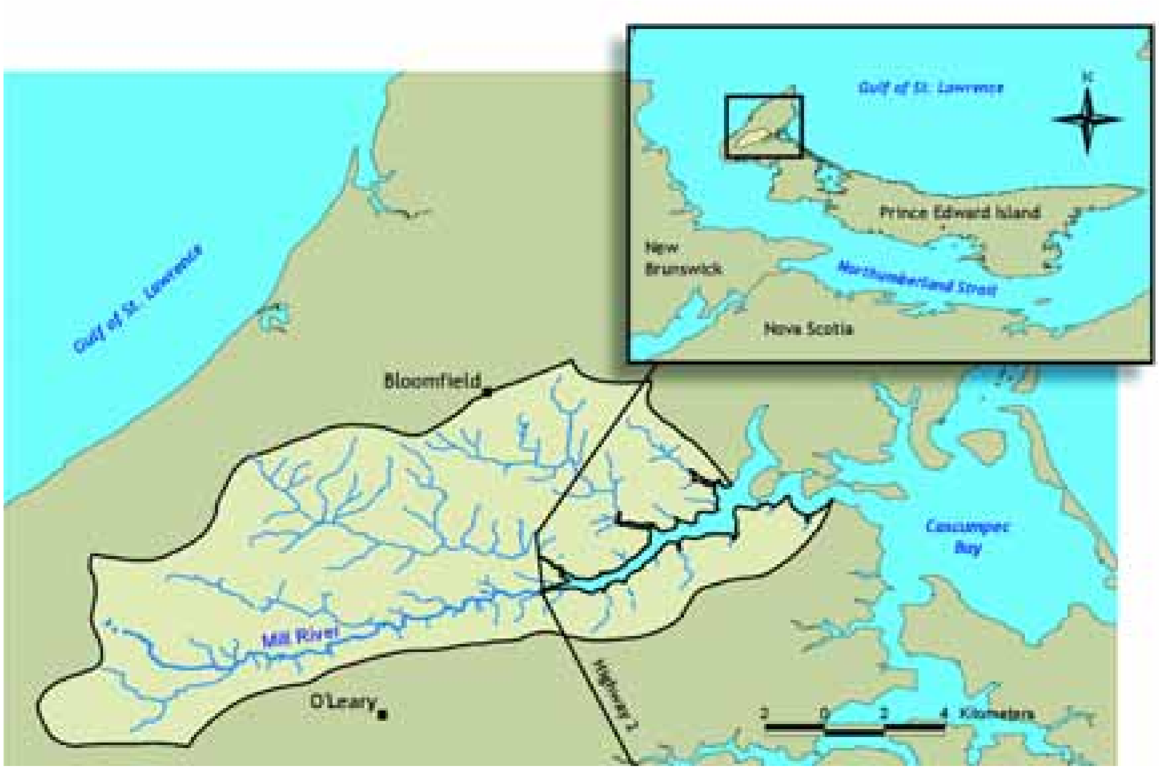
Major Threats to Natural Capital in the Mill River Watershed

- Loss of wetland to industrial agriculture and recreational development
- Soil erosion from potato fields contributing to soil loss and sedimentation of surface waters and marine environments
- Excessive phosphorus and nitrates and pesticide use from potato production endanger aquatic life in rich estuaries
- Nitrate contamination of drinking water from agricultural runoff

Mill River is a prime recreational area, with numerous cottages and resort and golf course developments along its edge. These land uses lead to a loss of wetlands and degradation of the natural capital on the lands.

Potato production in the Mill River Watershed has significantly increased since the early 1970s, altering the land use from forests to agriculture. The agricultural practices contribute to increased soil erosion. P.E.I. soils are highly susceptible to erosion due to their geography, geology and land use. Erosion rates are highly dependent on the slope of the fields and the management practices in place on those fields. Erosion rates on P.E.I. for unprotected, bare soil potato fields can be in excess of 20 tonnes/ha/yr. Soil losses at this magnitude result in nutrient loss equivelent to $70/ha/yr.[77]

Soil erosion also increases sedimentation of surface waters and marine environments, decreasing water quality and affecting marine life. The shellfish fishery, for example, is an important economic activity to Prince Edward Island residents. Average annual value of this fishery in the Cascumpec Bay and Mill River during the period of 1997 to 2000 was estimated to be over $300,000.[78] Siltation increases the costs of shellfish production by 20 percent, and elimination of silt would triple output.[79] Bacteria contamination from agricultural runoff creates additional



left: DU Canada right: Gilles Daigle below right: Ron Garnett

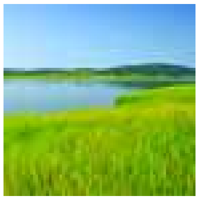
Mill River Watershed

problems for shellfish harvesting. Due to contamination, 75 hectares of the upper Mill River are closed for shellfish harvest, 82 hectares of the Mill River estuary are conditionally open, with the remaining 165 hectares unconditionally open for harvest.

Potato production increases the amount of nutrients (phosphorus and nitrogen) in the watershed, leading to a deterioration of water quality. Phosphorus and nitrogen loads from livestock produce approximately 323,000 kg of waste nitrogen and 240,000 kg of waste phosphorus per year.[80] In coastal P.E.I. waters, excessive sea lettuce populations occur in nutrient-rich estuaries and the plant material can fill the water column over broad areas. As the sea lettuce dies and decomposes, anoxic conditions (absence of oxygen) occur, resulting in the death of benthic shellfish. Fin fish caught within the sea lettuce mat will also die due to the anoxic conditions.[81] Pesticide runoff from agricultural use has harmful effects on fisheries.

Two documented fish kills have occurred on the Mill River since 1995. One incident involved an agricultural sprayer that overturned while moving to a potato field that resulted in product reaching a stream 33 metres away. The result was the loss of 40,000 salmon being reared at an aquaculture pond and 700 wild brook trout below the site of the spill. In 1996, 40,000 salmon were lost at the same aquaculture pond following 32mm of rain. Pesticides were found at a low level in the pond but not at levels considered toxic. The kill may have occurred as a result of problems compounded by silt and other substances found in runoff from agricultural lands.[82] Although no economic analysis of the Mill River fish kills were completed, an analysis was conducted on a fish kill on the Valleyfield River in eastern P.E.I. This analysis focused on a 1999 fish kill on the Valleyfield River, where a minimum of 2,500 brook trout were killed after runoff from potato fields entered the river. Looking at only the cost of the loss to the recreational brook trout fishery on this segment of the river, the author estimated the loss to be approximately $40,000.[83]

One thousand-two hundred people live in the Mill River watershed, and all are dependent upon groundwater for their drinking water. Evidence from research on P.E.I. is cause for concern both in terms of the distribution of nitrates in groundwater and implications for the future. Nitrate levels in groundwater have increased where land has been converted to more intensive agricultural cultivation. On the Mill River over the past 30 years, the nitrate levels have doubled. In some watersheds, 6 to 7 percent of household wells do not meet drinking water guidelines.[84]



The Net Benefits of Protecting Natural Areas or Converting Tilled Lands to Natural Areas

Table 9 presents high, low and 'best' estimates of the benefits and costs of protecting a natural area or converting a hectare of agricultural land to permanent vegetative cover that does not deplete the natural capital on that land.[85] They are modest compared to the estimates for the Grand River and Upper Assiniboine watersheds. This suggests that it will be more difficult to conserve natural capital in Mill River because the value of the land might be higher in agricultural and residential use than in a natural state. For example, at current average rental prices for agricultural land (ranging from $250 to $625 per hectare), the numbers suggest it is unlikely that agricultural land would be converted to natural areas because the net benefits are below these average rental rates. Belcher et al. argue that this conclusion may be flawed for two reasons. Firstly, because there is insufficient data to capture all the components of natural capital, the benefit estimates may be too low. Secondly, the buffer zones created by government policy to protect natural areas may depress surrounding land values, making some lands a good target for conservation. Table 9 is thus best viewed as a starting point for future work, rather than a definitive indicator of the net benefits per hectare of natural capital.

On the Mill River over the past 30 years, the nitrate levels have doubled. In some watersheds, 6 to 7 percent of household wells do not meet drinking water guidelines.

TABLE 9 – The Net Value of Conserving Natural Capital in the Mill River Watershed

Benefits (costs) $/hectare/year	High	Best Estimate	Low
Saved in government payments	135.00	90.00	45.00
Decreased sedimentation of conveyance/storage	2.35	1.15	0.57
Increased recreational fishing	33.80	16.52	8.15
Reduction in GHG emissions	13.35	8.90	4.45
Carbon sequestration	10.79	7.19	3.60
Increased wildlife hunting	2.24	1.12	0.56
Increased wildlife viewing	7.72	3.86	1.93
Wildlife – non-use and aesthetic values	32.04	16.02	8.01
Gross benefits	**237.29**	**144.76**	**72.27**
Program administration costs	(1.04)	(2.08)	(3.12)
Net benefits	**236.25**	**142.68**	**69.15**

iv

conclusions

right, below right: Brian Wolitski

This paper has illustrated the threats to Canada's natural capital due to the loss of natural areas to residential, commercial, industrial and agricultural use. These land uses are valuable to society, but they can also result in:

- Loss of wetlands, forests, riparian areas, and grasslands;
- Soil erosion and increased sedimentation of rivers and streams;
- Runoff of pesticides and nutrients from agricultural fertilizers and animal waste; and
- Air and water pollution from the resulting economic activities.

The paper has provided examples of how protecting and preserving natural areas adds to the wealth and well being of society today and into the future by:

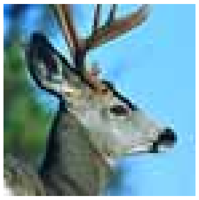
Protecting natural areas can help society avoid significant costs both today and into the future.

- Improving the quality of water in surface and groundwater;
- Decreasing water and waste treatment costs;
- Decreasing dredging costs to remove sediment from waterways;
- Increasing recreational opportunities such as fishing, swimming, hunting, and wildlife viewing;
- Providing aesthetic values;
- Protecting agricultural production on lands threatened by urbanization;
- Benefiting farm profits by engaging in beneficial management practices that coincide with protecting natural capital;
- Decreasing net greenhouse gas (GHG) emissions;
- Mitigating flooding;
- Improving air quality by protecting forests and reducing urban sprawl; and
- Protecting and enhancing habitats and ecological services of all kinds.

Conversely, the loss of natural areas may require society to find substitutes for all the valuable services noted above. The substitutes for natural capital may be far more expensive to build and operate than those provided by nature. For example, the waste services of wetlands in the lower Fraser Valley are worth at least $230 million per year in foregone treatment costs alone, and their value is many times higher if the infrastructure capital costs are added. Ignoring the value of natural areas is thus inefficient and costly for society today and for generations to come. Society also runs the risk of having no substitutes for natural capital, thus creating the potential for significant losses in our ability to sustain our economy and well being. The values provided by natural capital are far in excess of what has been illustrated in this paper because we do not attempt to compute many of the intangible benefits of nature – attributes we know exist, but cannot place a value on. The focus has been to show that protecting natural areas can help society avoid significant costs both today and into the future.

While this paper does not propose specific policies or programs for the protection of natural capital, it reveals that governments have the following important roles to play.

- Provide essential data on the physical quantities and attributes of natural capital and their changes over time. The case studies repeatedly illustrate the woeful lack of even the most basic data on the amount of natural capital in Canada. Efficient management of our natural capital resources requires knowing how much we have. The February 2, 2004 Speech from the Throne stated "…building on recommendations of the National Roundtable on the Environment and the Economy, the Government will start incorporating key indicators on clean water, clean air and emissions reduction into its decision making." However, without a far better understanding of our current stocks of natural capital in Canada, adopting the 'key indicator' approach will be irrelevant. No company



would stay in business long if its management did not know how much product was being produced, how much it cost to produce it, or the market price for the product. Why should we treat our natural capital – capital that sustains life on the planet – any differently?

- Assist in better decision making by coordinating and funding efforts to measure and value natural capital. Many agencies, public and private, are engaged in measurement and valuation processes. A national clearing-house for information would greatly assist these efforts.

- On Crown lands, governments should ensure that estimates of the value of the many benefits from natural capital attributes are compared to market values of the land before releasing that land for housing, commercial or industrial uses.

- When land is privately held, governments have a role to play in designing policies that provide incentives for landowners to conserve their land when the value of the natural capital from that land equals or exceeds its value in other uses. A number of policy instruments including rental payments, conservation easements, property tax rebates and a tradable conservation rights market have been used in other jurisdictions to meet conservation targets.

The federal government should take a strong leadership role by creating a national task force to: (1) fund and coordinate the comprehensive measurement of baseline data on the state of Canada's natural capital, to estimate its loss over the past decades and to ensure sustained measurement into the future; (2) ensure traditional economic analyses and forecasting approaches are revised to properly account for the services provided by natural capital and integrate the true cost of its degradation with economic decision making.; and (3) coordinate efforts to conserve and restore natural capital.

Without a far better understanding of our current stocks of natural capital in Canada, adopting the 'key indicator' approach will be irrelevant.

V

appendix

Methodology for Computation of Benefits and Costs of Conserving Natural Capital for the Agricultural Case Studies

right: DU Canada

The derivations used by Belcher et al. (2001) to compute the benefits and costs of conserving natural capital in the three agricultural case studies is detailed below. Similar measurement methodologies are used in each case.

Grand River Watershed

Foregone Government Program Costs

Converting land to permanent vegetative cover that is not used for agricultural production will save government expenditures on assistance payments.[86] On average, land withdrawn from producing row crops, used as pasture and for hay production in the Upper Grand River basin at the time of the study would save about $46 per hectare in government support.[87]

Erosion Control and Water Purification

Municipal water treatment costs in southern Ontario to remove sediment are estimated in the range of $9.34 to $28.02 per tonne of sediment (with a mean of $18.68), while those to remove phosphorus fall in the range of $5 to $500 per kg ($50 is used in the computation).[88]

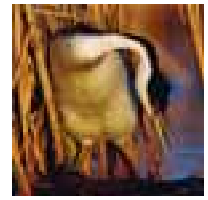
Reduced Sedimentation of Reservoirs and Flood Control

The costs associated with sedimentation are the maintenance costs of removing sediment. An estimate of the costs of ditch maintenance is $0.69/tonne of sediment, while that of maintaining water storage reservoirs is $1.62/tonne of sediment in the lake states, making total dredging costs equal to $2.31/tonne in year 2000 dollars.[89] Converting agricultural lands to permanent vegetative cover also reduces potential flood damage. Flood damage is estimated to fall by $2.10 to $7.50 per hectare of vegetated riparian zones consisting of 100 metre buffers on both sides of the stream channel.

Recreational Uses of the Grand's Watershed

Ontario residents spent approximately $30 per day participating in recreational fishing.[90] This translates to approximately 100 days per kilometre over the entire watershed area, or approximately 25 days per hectare of water. Decreasing sediment loads by one tonne in creeks and rivers of southern Ontario increases the number of fishing days by 1.47 and 4.41.[91] The value of the increased days of fishing ranges from $44.04 to $132.12/tonne of sediment removed from the rivers (with a mean of $88.08/tonne).

An estimate of the value of the services from natural capital for non-fishing freshwater recreation is $0.70 per hectare of riparian cover.[92] This value is conservative because the Grand River is a Canadian Heritage River, and will likely provide greater recreational opportunities than an average river in the northeastern United States.



Greenhouse Gas Services: Carbon Sequestration

The conversion of annual cropland to conservation cover will decrease net greenhouse gas (GHG) emissions in two ways. Annual crop production consumes significant quantities of fossil fuels. A hectare of land devoted to 33 percent grain corn, 20 percent soybeans, 24 percent alfalfa and 23 percent grains will generate 1.92 tonnes of GHG emissions per year from fossil fuel use.[93] No emissions are created on land in permanent vegetative cover. Land in permanent cover will also sequester more carbon in its soils than land tilled and planted annually due to decreased decomposition rates and increased plant residue inputs into the soil. The sequestration rates depend on the type of vegetative cover. A change from conventional crop tillage to permanent vegetative cover would increase carbon sequestered by 1.79 tonnes of carbon dioxide/ha/yr. If a tonne of carbon emissions has an implicit price of $10, the value of the incremental sequestration is $17.90/ha/yr.[94]

Wildlife

Ontario residents spent $200.6 million ($37/person/day) hunting wildlife in the province in 1996. The estimated willingness to pay by hunters for specific animals is $19.90/day for large mammals, $16.20/day for waterfowl, $11.60/day for other birds and $17.90/day for all hunting.[95] U.S. studies of willingness to pay to hunt allow a conversion of these figures to a per hectare measure. The increase in value associated with improved habitat from the permanent cover is estimated at $26.68/ha/yr (year 2000 dollars).[96]

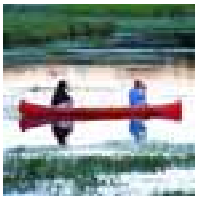
Ontario residents spent $410.9 million ($16/person/day) on wildlife viewing activities in the province in 1996. This included expenditures on accommodation, transportation, food and equipment. The estimated consumer surplus attributable to wildlife viewing was $7.50/day for Ontario residents. In 1996, in the Grand River watershed, there were 812,000 people-days (or 180 days/km^2/year) in wildlife viewing activities.[97] The increase in value from improved habitat is estimated at $46.97/ha/yr if expenditure estimates are used and $68.97/ha/yr if people's willingness to pay for wildlife viewing is also incorporated into the calculation.[98]

Administration Costs

If agricultural lands were converted from tillage to permanent cover (using a policy such as an annual payment to farmers for their conserved land), administration costs would be incurred. The administration costs for a cropland conversion program undertaken by the Prairie Farm Rehabilitation Administration (PFRA) in the late 1980s to 1990s in western Canada provides a benchmark estimate. Based on an enrollment of 306,044 hectares and total costs of approximately $5 million, an upper limit for the average administration cost is approximately $16.34/ha.[99] Assuming a 10-year agreement, the administration costs for the program are estimated to be approximately $1.63/ha/yr. Costs of compliance are assumed to be $2.08 per hectare.

Wildlife Depredation Compensation Costs

Increased populations of wildlife resulting from greater quantity and quality of habitat may cause greater levels of crop damage. In Ontario in 1998 wildlife damages cost field crop producers (corn, soybeans, wheat and forages) $26 million with a total loss to all farmers of $41 million.[100] Crop insurance does not appear to cover these costs. The cost of wildlife depredation per hectare is estimated at less than $1.00/ha/yr.



Upper Assiniboine River Basin

Foregone Government Program Costs

Removing land from agricultural production in the UARB would save approximately $12 per ha in government support. This estimate is based on government payments to producers in the UARB at the time of the study who participated in various crop support programs in the region. Farmers also qualify for crop insurance under Saskatchewan Crop Insurance Corporation (SCIC) programs. Data from that program indicate that taking land out of annual crop production can save the $3.51 per ha payment made by government.[101] Total savings in government program costs are $16.34/ha.

left, right: Darin Langhorst

Erosion Control and Water Purification

Unfortunately, there are no estimates for sediment delivery rates for the basin, therefore the estimates used for the Grand River watershed are applied to this case. Data are not available to undertake the specific measurement of the reduction in erosion costs, so estimates from the northern Great Plains of the U.S. are used to proxy the impact in the UARB. Using erosion imposed costs of approximately $1.15/tonne, the potential benefits of a conservation cover program in the UARB are between $1.34 and $9.34/ha/yr.[102] Estimating the benefits of reduced wind erosion is difficult due to limited data about both the sources and how people respond to blowing soil. Air quality benefits from reducing wind erosion are derived from a study of wind erosion in the United States. The U.S. figures are adjusted substantially downward to reflect the low population density of the UARB.[103] A figure of $2.10/ha/yr (year 2000 dollars) is used as the best estimate.[104] Conversion of agricultural land to wetlands and riparian zones is likely to provide relatively small direct water quality benefits in the basin.

Recreational Uses of the Upper Assiniboine's Watershed

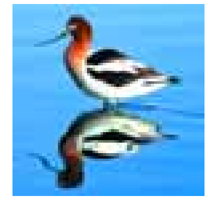
Recreational fishing is an important economic activity in the UARB, particularly in Lake of the Prairies, a reservoir on the upper reaches of the Assiniboine River, and in the Assiniboine River down to its convergence with the Red River in the City of Winnipeg. Saskatchewan and Manitoba residents spent $95.4 million ($29/person/day) and $124 million ($41/person/day) respectively on recreational fishing in 1996.[105] Willingness to pay for recreational fishing was estimated to be $10.70/person/day in Saskatchewan and $14.60/person/day in Manitoba. Therefore, the total willingness to pay per person per day was $39.70 in Saskatchewan and $55.60 in Manitoba in 1996 ($42.47/day and $59.49/day respectively in year 2000 dollars). People spent approximately 612,000 days (13.5 days/km^2) recreational fishing in the UARB in 1996. Again using studies from the United States, an estimate of the value of water-based recreational activities attributable to conversion of agricultural lands to natural areas is $0.91ha/yr.

Greenhouse Gas Services: Carbon Sequestration

Using the same methodology as in the Grand River case (i.e., using an estimate of $10 per tonne as the implicit price of carbon), the benefits of converting cropland (in this case from wheat) to permanent cover is estimated at $9.38/ha/yr. Enhanced soil uptake of carbon would result if the land is converted to grass, yielding $19.60/ha/yr.

Wildlife

Saskatchewan residents spent $33.7 million ($45/person/day) hunting wildlife in the province in 1996. The estimated consumer surplus at that time for hunting activities was $11.40/day for large mammals, $18.00/day for waterfowl, $12.40/day for other birds and $13.90/day for all types of hunting.[106] People spent approximately 64,000 days hunting large mammals and 60,000 days hunting small mammals, waterfowl and other birds in the UARB. Up-dating to year 2000 dollars, and assuming that cropland provides no habitat to game species of wildlife, the average hunting value for lands in permanent cover is $10.71/ha/yr and an upper bound is $19.11/ha/yr.[107]



In 1995, Saskatchewan residents spent $39.3 million ($17/day or $18.19/day in year 2000 dollars) viewing wildlife in the province. The estimated willingness to pay for wildlife viewing was $5.90/day in 1996 ($6.31/day in year 2000 dollars). People expended 608,000 days wildlife viewing in the UARB in 1996. Using the same methodology as in the other cases, the average value of conservation cover for wildlife viewing is approximately $4.16/ha. Again, using U.S. surveys, this translates into an upper bound total willingness to pay of $6.45/ha/yr (year 2000 dollars) in incremental benefits for wildlife viewing from the conversion of agricultural lands to permanent cover.

Administration Costs

The costs for the Grand River watershed were based on calculations for the UARB, so the estimates used here are identical.

Wildlife Depredation Compensation Costs

Wildlife depredation costs are estimated from compensation through crop insurance programs and crop depredation prevention programs. Using data from the Saskatchewan Crop Insurance Corporation and Saskatchewan Environment and Resource Management (SERM), Belcher et al. (2001) estimate the incremental costs associated with wildlife depredation are $0.64 per hectare on average.

Mill River Watershed

Savings in Government Program Costs

Data on average payments for P.E.I. as a whole indicate the foregone program costs because data specifically for Mill River are not available. A best guess estimate is that agricultural land in P.E.I. receives approximately $90/ha in government program payments.

Erosion Control and Water Purification

Erosion and sedimentation delivery rates for the Grand River watershed were used as a proxy because data for Mill River were not available. Unfortunately Belcher et al. (2001) found no data linking nitrogen and phosphorus erosion to land use and they could not use the Grand River data as the region was too different from that of Mill River. The costs of removing excess sediment from ditches and water storage facilities is estimated using data from the northeast U.S. at $1.53 per tonne sediment removed. However, estimates of the cost of removing sediments from highway ditches on P.E.I. by the Department of Transportation are estimated to be much higher at $35.00/ton. This includes the cost of excavation, trucking, disposal, reshaping the ditch, seeding, and erosion control.[108]

Fisheries

Both recreational and commercial fishing are important in the watershed. The reduction in water quality (as described above) has affected both types of fisheries, but precise data on the damages are not available. P.E.I. residents spent $1.5 million ($7.49/person/day in year 2000 dollars) on recreational fishing in 1996.[109] Non-resident recreational fishers are also quite important to the local economy. The value of recreational fishing to P.E.I. residents in 2000 was $1.6 million per year and $14.6 million to all fishers regardless of residence.[110] There are no estimates of the impact of increased sedimentation on freshwater fisheries, so using Ontario figures, decreasing sediment loads

will increase recreational inland fishing benefits by $22.02/tonne for residents and $176.40/tonne for non-residents. No data were available to quantify the change in freshwater fishery value associated with a change in nutrient (nitrogen and phosphorus) loads in P.E.I.

Greenhouse Gas Services: Carbon Sequestration

Following the same methodology as in the other agricultural case studies, converting agricultural land to permanent cover would save 0.89 tonnes/ha/yr of CO_2 equivalent emissions. Converting annual cropland to conservation cover will increase soil carbon stocks by 0.719 tonnes/ha/yr, for a value of $11.60/ha/yr to $14.00/ha/yr.

Wildlife

P.E.I. residents spent $1.9 million over 5,000 person-days ($25.68/person/day in year 2000 dollars) hunting wildlife in the province in 1996.[111] The estimated consumer surplus for hunting activities were $14.87/person/day for all hunting (year 2000 dollars). Converting these figures into a per hectare figure, the value of a marginal hectare of conservation cover is approximately $0.56, a number considerably lower than in the other provinces.

Wildlife viewing expenditures by P.E.I. residents for 41,000 person-days totaled $3.1 million, or $10.70/person/day. Willingness to pay for wildlife viewing was $5.46/person/day.[112] The value of a marginal hectare of conservation land thus equals $1.93, again substantially lower than in other provinces. The value may be affected by the exclusion of non-resident tourists who annually spend $300 million in P.E.I.

Administration Costs

The costs for the Grand River watershed were based on calculations for the UARB, so the estimates used here are identical.

Wildlife Depredation Compensation Costs

Because there are no wildlife depredation compensation programs in P.E.I., it is assumed that wildlife depredation costs in the Mill River watershed are zero.

left: Andrew McLachlan below: Brian Wolitski

endnotes

1 Research assistance for this report was provided by Matthew Bourke, Catherine Cheng, Judy Harris, Shahrokh Shahabi-Aziz, James Steidle, Alex Tu and Linda Wong. I am grateful for the insightful reviews provided by C. Edwards, L. Brown, R. Trout and K. Belcher.

2 It is beyond the scope of this paper to evaluate specific land use policies. The effects on natural capital of government regulation of land use is a complex subject that merits its own study.

3 The notion that other forms of capital can be substituted for natural capital has been called weak sustainability. Sustainability, broadly defined, is the ability of the economy to maintain a flow of production necessary to ensure non-decreasing consumption per capita indefinitely. To sustain production, the economy needs a constant supply of the inputs that are essential in the sense that without these inputs, no output could be produced. The relationship between natural capital and sustainable output then depends on whether natural capital is essential or not, i.e., what are the substitution possibilities between factor inputs.

4 Trust for Public Land (1999). The economic benefits of parks and open space: How land conservation helps communities grow smart and protect the bottom line, as cited in A. Sauer (2002) *The value of conservation easements, the importance of protecting nature and open space, world resources institute, discussion paper*, as presented by the West Hill Foundation for Nature, Inc., December 1, 2002.

5 The concepts of weak and strong sustainability reflect how essential natural capital is to the economy and environment. Weak sustainability requires the maintenance of an aggregate stock of capital (natural, human and manufactured) at a level necessary to ensure indefinite production. All of the forms of capital must therefore be perfectly substitutable for each other. Strong sustainability says that specific forms of natural capital are essential (they do not have substitutes), and stocks of these resources must remain intact over time to ensure continued production. We have an imperfect understanding of what forms and minimum amounts (in terms of quantity and quality) of natural capital are essential and how to sustain stock sizes needed to ensure non-decreasing production, consumption, and hence, human survival. Some forms of natural capital are clearly essential – our atmosphere and water, for example.

6 Statistics Canada's Environment division is developing natural capital stock accounts. Environment Canada and the National Round Table on the Economy and Environment have an environmental indicator series. These efforts are a good start, but are not comprehensive.

7 Meyer, J.L., Kaplan, L.A., Newbold, D., Strayer, D.L., Woltemade, C.J., Zedler, J.B., et al.(2003). *Where rivers are born: The scientific imperative for protecting small streams and wetlands*. Retrieved August 2004, from http://www.sierraclub.org/cleanwater/reports_factsheets.

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31 Fowler, E. P. (1992). Building cities that work. Montreal, QC: McGill-Queen's University Press.

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34 According to 2001 GVRD land use compilations, there are 207,280 hectares of non-disturbed, agricultural, harvesting/research and recreational lands left in the GVRD. Excluding those lands in the North Shore and Electoral Area A (which also excludes the University Endowment Lands outside the University of British Columbia), there are 96,348 hectares of the mentioned land types remaining, most of which lies in the Fraser Valley floor.

35 Information provided by 2001 GVRD land use compilations.

36 Palda, F. (1997). The zero-tax city: Without civilizing the financing of city services, cities are doomed to decline, *The Next City* (Spring): 40-47.

37 Lavkulich, L. M., Hall, K. J. and H. Schreier (1999). Land and water interactions: Present and future. In M. Healey (ed.), *Seeking sustainability in the Lower Fraser Basin: Issues and choices* (pp. 170-201). Vancouver, BC: Institute for Research and the Environment Press Westwater Research.

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39 For example, over half of the 118 kilometers of dikes from Hope to Mission are considered to be too low, with about 17 percent low by more than 0.4 meters, due in part to improved flood modeling, changes in river alignment and sediment deposition. See Fraser Basin Council (2003). *A snapshot on sustainability: State of the Fraser Basin report*. Retrieved August 2004, from http://www.fraserbasin.bc.ca/publications.

40 The 2001 Canadian census showed that over 325,000 people live in 100,000 homes in the floodplain of the Fraser River. This constitutes a 168 percent increase in the last 20 years. "Considering the huge amount of residential, commercial and infrastructure development on the floodplain since 1948, if dikes failed and we had a similar flood today, estimates for damage and recovery range from $2-10 billion." (*Fraser Basin News*, vol. 6. no. 2. Fall 2003).

41 Fraser River Action Plan (1998). *Wild, threatened, endangered and lost streams of the Lower Fraser Valley: Summary report 1997*. Lower Fraser Valley stream review, Vol. III. Retrieved August 2004, from http://collection.nlc-bnc.ca/100/200/301/dfo-mpo/lower_fraser_valley/wild_threatened_endangered/229864.pdf

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42 The B.C. government initiated the Protected Areas Strategy in 1993 to develop a comprehensive protected area network in B.C. The Protected Area Strategy forms part of the Regional and Land Resource Management Planning for the Province, which has completed strategic planning on 73 percent of the Province. See http://srmwww.gov.bc.ca/md/lrmp/data/policy/slupmap.htm.

43 2001 Census of Canada.

44 The objective of the Agricultural Land Reserve (ALR) was to "protect high-quality agricultural land for future food production rather than to convert such land to urban uses." Lavkulich, L., K.J. Hall and H. Schreier (1999) Land and Water Interactions: Present and Future. In M. Healey (ed.), *Seeking sustainability in the Lower Fraser Basin: Issues and choices* (pp. 170-201). Vancouver, BC: Institute for Research and the Environment Press, Westwater Research. The ALR is a controversial policy. For example, from the late 1980s to 1994, the development of golf courses was allowed on the ALR. In November 2002, the rules governing the ALR were changed again to decentralize and devolve authority from the Agricultural Land Commission to six regional panels. The impact of this change is not yet known, but there is concern due to pressures on regional commissions to allow land conversion to other uses.

45 Northwest Environment Watch and Smart Growth BC (2002). *Sprawl and smart growth in Greater Vancouver – A comparison of Vancouver, British Columbia, with Seattle, Washington*. Retrieved August 2004, from www.northwestwatch.org/press/vancouvergrowth.html.

46 Table 1. Agricultural Production in the Fraser Valley – 1986-1996 from p. 12 derived from Statistics Canada Census of Agriculture 1986, 1991, 1996.

47 Elliot, B. et al. (1999). p. 160.

48 Lavkulich, L.M. (1999). p. 179.

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50 Schreier, H., Hall, K. J., and S. J. Brown (1999). Agriculture: An important non-point source of pollution. In C. Gray and T. Tuominen (eds.), *Health of the Fraser River aquatic ecosystem* Vol. III (pp. 83-99). Vancouver, BC: Fraser River Action Plan.

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53 IBA News Canada (1999), as cited in the BC Naturalist Magazine, Fall 1999.

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58 Obarska-Pempkowiak, H. (1997). Seasonal variations in the efficiency of nutrient removal from eomestic effluent in a quasi-natural field of reeds. In C.Etnier and B. Guterstam (eds.), *Ecological engineering for wastewater treatment* (2nd ed.), (pp 213-214). Boca Raton, FL: CRC Press.

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60 For example, the low estimate of 17 percent of the 273 kg/ha/yr of nitrogen applied to agricultural land gets into surface water. This means that 46.4 kg/ha/yr of excess nitrogen must be removed by water treatment plants to prevent an increase in nitrogen levels. This number is well within the estimates of nitrogen absorption by wetlands. A similar calculation for phosphorus requires wetlands to absorb 14.3 kg/ha/yr, again well below the lowest estimate of the wetland capacity.

61 This assumes that 46.4 kg of excess nitrogen/ha and 14.3 kg of excess phosphorus/ha must be removed each year, amounts within the removal capacity of the wetlands. The opportunity cost of removing these nutrients if done by a waste treatment plant, using the lowest estimate is $3.04/kg for nitrogen and $21.85/ kg for phosphorus, which means that the total cost per hectare is approximately $140 for nitrogen and $312 for phosphorus. That means that each hectare of wetlands removes $452 worth of nitrogen and phosphorus per year. If 40,000 hectares of the Fraser Valley's wetlands were involved in this process, their total value per year would be $18 million. Similar calculations are done for higher costs of physical treatment.

62 These numbers come from a variety of studies. The dollar amounts assume 2 percent inflation per year since the mid-1990s and a Canadian-U.S. exchange rate of 1.35.

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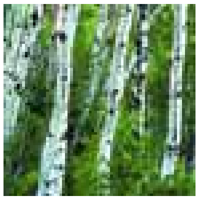

nomic balance. Delta, BC: Burns Bog Conservation Society. Values are converted from U.S. to Canadian dollars and presented in 2004 dollars.

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69 Grand River Conservation Authority (2000). *Grand River conservation strategy*. Retrieved August 2004, from http://www.grandriver.ca/Grandstrategy/background.cfm.

70 Grand River Conservation Authority (2001). Personal Communication to Belcher et al. Belcher et al. note that the amount of land identified as appropriate for conservation cover will be sensitive to grain prices with higher (lower) prices decreasing (increasing) the supply.

71 See Table 7 in Belcher et al. (2001).

72 The values for reduction in government payments to agriculture reflect programs in place at the time the case studies were done. As these programs change over time, the numbers may not reflect the current situation. Also note that whether one views a reduction in government payments to a sector as a benefit or not depends on a host of complex factors such as the perspective of the study (national or local, what type of program is in place, how are the funds are raised to pay for the program, and so on). As the estimates of the benefits of conserving natural capital on agricultural likely underestimate the total benefits, inclusion of this item is warranted.

73 Environment Canada, SaskWater and Manitoba Conservation (2000). *Upper Assiniboine River basin study*, Main Report.

74 Methods used to compute the benefits and costs for the Upper Assiniboine River Basin are shown in the Appendix.

75 These data are taken from Belcher et al. (2001). See Table 22 for notes explaining each measure.

76 Belcher et al. (2001).

77 Jacobs, P. (2000). *Soil conservation for potato production*. A booklet on best management practices for potato production. Prepared for the Canada-PEI Water Annex to the Federal/Provincial Framework Agreement for Environmental Cooperation in Atlantic Canada.

78 Gloutney, M. (2001). Ducks Unlimited Canada, Personal Communication to Belcher et al. (2001).

79 Thompson, G.R.(1998). *Bacterial contamination in Prince Edward Island surface waters from agricultural sources*. Prepared for Canada-Prince Edward Island water annex to the federal/provincial framework agreement for environmental cooperation in Canada, as cited in Belcher et al. (2001). Unfortunately, Belcher et al. were unable to quantify changes in shellfish productivity associated with a decrease in sediment or nutrient loads in incoming fresh water due to a lack of data.

80 Gloutney, M. (2001). Ducks Unlimited Canada, Personal Communication to Belcher et al. (2001).

81 Raymond, B.B. (2002). Nutrient and chlorophyll trends in Prince Edward Island estuaries. In D.K. Cairns (ed.), *Effects of land use on fish, shellfish, and their habitats on Prince Edward Island* (Can. Tech. Rep. Fish Aquat. Sci. No. 2408).

82 Anon. (1998). *Summary of activities surrounding recent fish kills on P.E.I., October 1998*, Government of Prince Edward Island Report, Contact: James Mutch, Hydrogeologist, 902-368-5599, jpmutch@gov.pe.ca

83 MacDonald, K., Dewis, S., Hennigar, P., Percy, R., Boyce, D., and D. Sawyer (2000). *Application of environmental damage assessment and resource valuation processes in the Atlantic Region*. Presented at the 43rd Annual International Conference, Great Lake, Great Rivers 2000: A Vision for Tomorrow.

84 Somers, G., B. Raymond and W. Uhlman (1999). *P.E.I. Water Quality Interpretive Report*. Pp 22-25. A report prepared for the Canada-Prince Edward Island Water Annex Agreement.

85 Methods used to compute the benefits and costs for Mill River are shown in the Appendix.

86 Government support programs in place in this region include the federal-provincial crop insurance program, the Net Income Stabilization Account (NISA), Market

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Revenue Insurance (MRI), the Canadian Farm Income Program (CFIP), and other programs.

87 This estimate is based on government payments to producers in the Upper Grand River basin who participated in the NISA program in 1999. It includes the government share of payments for crop insurance, NISA, MRI, AIDA (Agricultural Income Disaster Assistance, the precursor to CFIP) and other programs. A similar analysis for Ontario as a whole resulted in an estimate of average income support of approximately $65/ha, significantly higher than the value calculated here for the Upper Grand watershed.

88 Estimates for sediment treatment are from Fox, G. and E.J. Dickson (1990). The economics of erosion and sediment control in southwestern Ontario, *Canadian Journal of Agricultural Economics* 38: 23-44; and those for phosphorus control from D.W. Draper and Associates Ltd. (1997). *Phosphorus trading program evaluation and design: Bay of Quinte remedial action plan*. Prepared for the Ontario Ministry of Environment and Energy, Environment Canada, Lower Trent Region Conservation Authority, Trent-Severn Waterway and the Bay of Quinte RAP Implementation Advisory Committee.

89 Ribaudo, M.O. (1989). *Water quality benefits from the Conservation Reserve Program*. Economic Research Service, U.S. Department of Agriculture, (Agricultural Economic Report No. 606). Washington, D.C.: U.S. Government Printing Office.

90 Environment Canada (2000). Numbers are in year 2000 dollars, converted from Environment Canada's 1996 dollars estimates. Note that the estimates below are one way to value the benefits of recreational fishing in the Grand River. Other studies may provide additional estimates.

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92 Feather, P., Hellerstein, D., and L. Hansen (1999). *Economic Valuation of Environmental Benefits and Targeting of Conservation Programs: The Case of the CRP*. U.S. Department of Agriculture (Agricultural Economic Report No. 778). These researchers estimated that 39 percent of the total freshwater recreation value can be attributed to non-fishing freshwater based recreation. In the Northeast States Region, approximately 17 percent of this non-fishing recreation value can be attributed to river recreation. Using estimates of total willingness to pay for freshwater recreation of $10.60/ha, the value of other freshwater recreation on rivers is estimated to be $0.70/ha of conservation land ($10.60*0.39 (proportion attributable to other freshwater recreation)*0.17 (proportion attributable to river recreation)).

93 Based on weighted sum of 1996 Census of Agriculture statistics on cropping patterns for the municipalities of Wellington, Waterloo, Perth and Brant. Statistics Canada (1997). *Census of Agriculture: Agricultural Profile of Ontario*.

94 Smith, W.N., Desjardins , R.L., and B. Grant (2001). Estimated changes in soil carbon associated with agricultural practices in Canada, *Canadian Journal of Soil Science* 81: 221-227.

95 Environment Canada (2000).

96 The estimates are derived from a conservative adaptation of hunters' willingness to pay for pheasant hunting trips as found in Feather et al. (1999). See Belcher et al. (2001) for details on the computation.

97 Environment Canada (2000).

98 The average value of one hectare of land converted to permanent cover is $37.71/ha/yr.

99 Prairie Farm Rehabilitation Administration (2001). Personal communication with Mark Dumanski as cited in Belcher et al. (2001).

100 Ontario Soil and Crop Improvement Association (2000). *Wildlife impact assessment of Ontario agriculture.* Submitted to Ontario Agriculture Commodity Council and Agricultural Adaptation Council.

101 The data are for a period in which no major crop failures occurred. They thus may understate the savings in insurance payments made by government.

102 Ribaudo, M.O. et al. (1989). CRP What Economic Benefits? *Journal of Soil and Water Conservation* 44(5): 421-424.

103 Ibid.

104 The figure derived from Ribaudo, M.O. et al. (1989) of $42.11/ha/yr was obtained from a survey of wind erosion damages in New Mexico. It was discounted by 95 percent to reflect Belcher et al.'s (2001) estimate of the differences in the population densities between New Mexico and the UARB.

105 Environment Canada (2000).

106 Ibid.

107 See Belcher et al. (2001) for the computations of these estimates. The methodology is the same as in the Grand River case.

108 Personal Communication with Brian Thompson, Environmental Engineer, P.E.I. Department of Transportation, Charlottetown, P.E.I. 902 368-5185, bfthompson@gov.pe.ca

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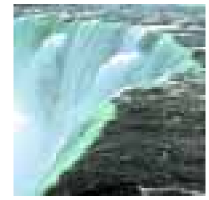
112 All values are adjusted to year 2000 dollars.



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