Status of Current Work – Measurement and Valuation of Ecological Goods and Services in Canada

Final Report

Submitted by

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1 Executive Summary

The earth's natural capital provides land, resources and a flow of ecosystem services. Watersheds that cover our landscapes consist of forests, wetlands, grasslands and rivers that act like giant utilities providing ecological services for local communities as well as regional and global processes that we all depend upon for life-supporting services. Ecosystems provide a plethora of services including the storage of flood waters, water capture and filtration by watersheds, air pollution absorption by plants, and climate regulation resulting from carbon storage in trees, plants and soils. However, they are undervalued in our market economy. They are worth billions of dollars per year, but need to be valued more accurately because their loss has massive economic impacts, threatening health, food production, climate stability, and basic needs such as clean air and water.

The recognition and valuation of ecosystem services are emerging trends at the global, national and regional level. For example, the United Nations Millennium Ecosystem Assessment (MA) reported on the condition of the world's ecosystems and their ability to provide services today and in the future.[1] The MA found that over the past 50 years humans have changed the Earth's ecosystems more rapidly and extensively than in any other period in human history. Their assessment concluded that approximately 60 per cent (15 out of 24) of the world's ecosystem services are being degraded or used unsustainably, including fresh water, air and water purification, and the regulation of regional and local climate. The full costs of these losses are difficult to measure, but the MA concludes that they are substantial.[2] Several of the studies that this paper reviews have either adopted the MA framework or used components of the study's classification system. As communities and governments are beginning to recognize the essential services that natural areas provide, more research and policy options are being explored.

This report was commissioned by Environment Canada to review current work that has identified, quantified and valued ecological goods and services (EGS) in Canada. The measurement of the qualitative and quantitative value of ecosystem services may be harnessed to allow for better environmental and economic management and inform better land use, environmental management, and policy decisions. The following sections summarize the state of current EGS work in Canada, including:

1) The ecological goods and services that have been studied, frameworks and methods used, and the outcomes/values reported as well as policy and planning implications.

2) The existing models used to map and value EGS, as well as the data sets and measurement information used to populate these models.

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1 http://www.millenniumassessment.org/en/Condition.aspx

2 Millennium Ecosystem Assessment. 2005. "Ecosystems and Human Well-being: Synthesis." Island Press. Washington, DC.

3) A summary table organized by EGS categories with regards to Environment Canada's responsibilities for water, air, soil, conservation and biodiversity and landscape management.

This review on the status of EGS research in Canada demonstrates that interest in defining and valuing ecological goods and services is growing, Regionally, studies have been undertaken to assess the value of EGS in the boreal region including the Mackenzie watershed, the Great Lakes Basin, the southern Ontario Greenbelt, as well as the economic value of nature-related activities across Canada. Watershed and wetland studies have been conducted in watersheds such as Broughton's Creek in southwestern Manitoba, the Credit Valley in southern Ontario, Lake Winnipeg and Lake Simcoe. The value of conserving natural cover in agricultural regions was assessed in several case studies for the Lower Fraser Valley in British Columbia, Grand River watershed in southern Ontario, the Upper Assiniboine river basin in Saskatchewan, and the Mill River watershed on PEI.

In the studies reviewed, carbon storage services and water-related services such as water regulation by wetlands and water filtration services provided by forests had the highest assessed value. Climate regulation through carbon storage and sequestration has become one of the most popular ecosystem services studied. This is because of its importance in terms of the rapid increase of carbon dioxide in the atmosphere and the predicted damages due to climate change. In the studies reviewed, values for carbon storage range from $15 to $820 per hectare.

Water regulation and supply services provided by wetlands and forests feature prominently in many of the studies that evaluated non-market EGS. In the case of the assessment of the southern Ontario Greenbelt's eco-services, water filtration by forests and wetlands was measured as the avoided cost of increased human-built water treatment as a result of additional forest/wetland cover losses in the watersheds. In the Pimachiowin Aki (P.A.) study, water related values were based on contingent valuation transferred from an earlier study where the average willingness to pay for improved water conservation and protection by Manitobans was approximately $420 per household per year. Water supply services were estimated based on the water supply volumetric value from a study of the Assiniboine Aquifer water supply ($40,000 to $80,000 per cubic metre). Applied to the main rivers volume of flow in the P.A. study the potential economic value was estimated between $0.27 to $5.55 billion. Water regulation values reported in the studies reviewed ranged from $408/ha/year to $8, 209/ha/year.

The value of recreation and nature-based tourism are both becoming relatively well developed in terms of the availability of EGS research and values. Many jurisdictions or organizations that have begun EGS research begun their work by looking at the more easily obtainable information and readily available economic information related to natural capital and EGS. Often the starting point is to compile values on tourism and recreation because statistics on use, recreational activities/habits, spending and costs are compiled by tourism departments, parks and protected areas.

Many of the reports identify data limitations for measurement and valuation of ecosystem goods and services because of a lack of ecological and economic information. This includes a lack of data on the current state of ecosystems and the services they provide, as well as a lack of information on how these services may change under different conditions such as changing land use. Measuring the value of goods or services is fairly straightforward when they have a market-determined value. However, non-market values of ecosystem services are much more difficult to quantify because they do not have established market prices.

Suggestions for Future Research:

1) Municipal and provincial as well as conservation/watershed authorities need to begin to identify, measure, and monitor EGS as part of their jurisdictional reporting. All levels of government should develop natural capital accounts as part of an accounting system that includes reporting on:

- the annual state and extent of land/water cover including changes over time.
- the annual measurement of key and critical EGS including changes over time (e.g. air quality, water quality, carbon storage, waste treatment and flood control)
- the annual value of key and critical EGS in terms of market and non-market values that reflect changes over time; and,
- an account of the losses in value due to human impact on ecosystems and their EGS including damages incurred that result in a decline in the flow of EGS as well as the cost of restoration and reclamation.

2) The development of a standard approach for the measurement and valuation of EGS for Canada would greatly improve this area of research. A national working group of key academic researchers and practitioners could develop a model that would include models by region/dominant land cover/land use with allowance for regional adaptation.

3) EGS and agricultural land use is a research area that needs to establish a standardized approach to measure the non-market ecosystem services provided by agricultural lands. There is also a need to establish values based on the level of ecosystem services provided, as well as those best management practices that should be rewarded and programs to implement incentive based payments.

4) Promotion of applied EGS research to support policy decision-making. There is a need for studies that look at changes in marginal values (rather than total values), and the impacts that various policies have on ecological goods and services. This would help decision-makers choose between competing policies or resource uses, in light of whether the changes in net benefits from a decision are greater or equal to the costs involved.

2 Introduction

2.1 Canada's Natural Capital

The earth's natural ecosystems are stocks or assets that provide resources and a flow of services. Watersheds that cover our landscapes consist of forests, wetlands, grasslands and rivers that act like giant utilities providing ecological services for local communities as well as regional and global processes that we all depend upon for life-supporting services. Ecosystems provide a plethora of services including the storage of flood waters, water capture and filtration by watersheds, air pollution absorption by plants, and climate regulation resulting from carbon storage in trees, plants and soils. However, as we do not pay directly for these services, they are undervalued in our market economy. They are worth billions of dollars per year, but need to be valued more accurately because their loss has massive economic impacts, threatening health, food production, climate stability, and basic needs such as clean air and water.

The world's economies are based on ecological goods and services. Human life itself depends on the continuing ability of the natural environment to function and provide its many benefits. Yet, economic measures do not reflect this dependence. While Canadians recognize the importance and value of the environment to their well-being, the conditions and values of Canada's natural capital assets are not accounted for in measures of economic progress like the Gross Domestic Product (GDP) or in Canada's national accounts. Although Statistics Canada has established satellite accounts for marketable products such as timber and potash, the full value of Canada's environmental assets (natural capital) is not known.

2.2 Identification of Ecological Goods and Services (EGS)

Ecological goods and services (EGS) are the benefits derived from ecosystems. These benefits are dependent on ecosystem functions, which are the processes (physical, chemical and biological) or attributes that maintain ecosystems and the people and wildlife that live within them. EGS include products received from ecosystems (e.g. food, fibre, clean air and water), benefits derived from processes (e.g. nutrient cycling, water purification, climate regulation) and non-material benefits (e.g. recreation and aesthetic benefits).[3]

3 Millennium Ecosystem Assessment. 2003. Ecosystems and Human Well-Being: A Framework for Assessment. World Resources Institute, Island Press. Washington, D.C.

The following table provides a list of ecosystem function, processes and the corresponding ecosystem services (Table 1).

Table 1: Ecosystem Functions, Processes and Corresponding Ecosystem Services

Functions	Ecosystem Processes or Components	Ecosystem Services
Gas regulation	Role of ecosystems in bio-geochemical cycles (e.g. CO2/O2 balance, ozone layer)	UVb protection by ozone, maintenance of air quality
Climate regulation	Influence of land cover and biological mediated processes on climate	Maintenance of a favourable climate, carbon regulation, cloud formation
Disturbance prevention	Influence of ecosystem structure on environmental disturbances	Storm protection, flood control, drought recovery
Water regulation	Role of land cover in regulating runoff and river discharge	Drainage, natural irrigation, transportation
Water supply	Filtering, retention and storage of fresh water	Provision of water by watersheds, reservoirs and aquifers
Soil retention	Role of the vegetation root matrix and soil biota in soil retention	Prevention of soil loss/damage from erosion/siltation; storage of silt in lakes, and wetlands; maintenance of arable land
Soil formation	Weathering of rock, accumulation of organic matter	Maintenance of productivity on arable land; maintenance of natural productive soils
Nutrient cycling	Role of biota in storage and re-cycling of nutrients (e.g. nitrogen)	Maintenance of healthy soils and productive ecosystems; nitrogen fixation
Waste treatment	Role of vegetation and biota in removal or breakdown of xenic nutrients and compounds	Pollution control/detoxification, filtering of dust particles, abatement of noise pollution
Pollination	Role of biota in the movement of floral gametes	Pollination of wild plant species and crops
Biological control	Population and pest control	Control of pests and diseases, reduction of herbivory (crop damage)
Habitat	Role of biodiversity to provide suitable living and reproductive space	Biological and genetic diversity, nurseries, refugia, habitat for migratory species
Food production	Conversion of solar energy, and nutrient and water support for food	Provision of food (agriculture, range), harvest of wild species (e.g. berries, fish, mushrooms)
Raw materials	Conversion of solar energy, nutrient and water support for natural resources	Lumber, fuels, fodder, fertilizer, ornamental resources
Genetic resources	Genetic materials and evolution in wild plants and animals	Improve crop resistance to pathogens and crop pests,

		health care
Medicinal resources	Biochemical substances in and other medicinal uses of biota	Drugs and pharmaceuticals, chemical models & tools
Recreation	Variety in landscapes	Ecotourism, wildlife viewing, sport fishing, swimming, boating, etc.
Education, Culture & Spirituality	Variety in natural landscapes, natural features and nature	Provides opportunities for cognitive development: scenery, cultural motivation, environmental education, spiritual value, scientific knowledge, aboriginal sites
Source: Wilson, S. 2008. *Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services*. David Suzuki Foundation. Vancouver, Canada.[4]		

Ecosystem processes or functions characterize ecosystems. Using the ecosystem classifications by ecosystem function developed from a number of published sources, the potential ecosystem services by ecosystem type or land cover/land use can be identified.

The Millennium Ecosystem Assessment (MA) was established in 2001 as an international work programme run by 1300 researchers from 95 countries, which reported in March 2005. The MA focused on ecosystem services and how changes in them have affected and will impact upon human wellbeing. The MA is the most comprehensive review of the state of the planet ever conducted. The results suggest that human activities have changed most ecosystems and threaten the Earth's ability to support future generations.
They categorized ecosystem goods and services as: *provisioning services* such as food, fuels and fibres; *regulating services* that affect the climate, disease outbreaks, wastes and pollination; *cultural services* that provide aesthetic, recreational and spiritual value; and *supporting services*, such as nutrient cycling and water purification. Their assessment ascribed ecosystem services by global eco-region types including wetlands, forests, dryland systems, and cultivated systems. For example, the assessment identified the following ecosystem services for wetland systems:[5]

- Supporting Services
  a) soil formation
  b) nutrient cycling
- Regulating Services
  a) Water regulation (hydrological flows)
  b) Water purification and waste treatment
  c) Erosion regulation
  d) Natural hazard regulation
  e) Climate regulation
  f) Pollination
- Provisioning Services

4 Adapted from: De Groot, R.S., 2002. "A typology for the classification, description and valuation of ecosystem functions, goods and services." Ecological Economics. 41: 393-408.

5 Millennium Ecosystem Assessment . 2005. Ecosystems and Human Well-being: Wetlands and Water Synthesis. World Resources Institute. Washington D.C.

a) Food & fiber
b) Wood fuel
c) Biochemical
d) Freshwater
e) Genetic materials

- Cultural Services
  a) Spiritual and inspirational
  b) Aesthetic
  c) Recreation & tourism
  d) Educational

2.3 Valuing Ecological Goods and Services

The growing fields of environmental and ecological economics are developing methodologies and techniques for the valuation of ecosystem services, and more broadly, natural capital accounting. Valuing ecological services involves identifying and measuring the various goods and services being provided by the site under study. The various elements of value for each of the EG&S can be identified with reference to the Total Economic Value framework. Each of these elements can then be ascertained either by one of several approaches including replacement/damage cost, revealed preference; stated preference or benefit transfer method. Each of these is described below.

2.3.1 Total Economic Value

In order to determine the value of the environment, the unpaid values of nature's services must first be revealed. The UN's Millennium Ecosystem Assessment (MA) poses three main domains as critical for successful policies: the biophysical information about the ecosystem status and process, the socioeconomic information about the context in which and for which the decision will be made and the information about the values, norms and interests of key stakeholders shaping and affected by decisions. The MA identifies the Total Economic Value (TEV)i as the most widely used framework to identify and quantify the contribution of ecosystem services to human well being.

Total economic value distinguishes between use values and non-use values, but these values are incorporated and are defined in monetary terms, there are three main categories of values used to determine the TEV:

- use values
- non-use values
- option values

TEV is composed by use values, option values and non-use components. Often TEV is reported as the sum of use value and non-use values or passive values. Use values can be direct when goods and services are exchanged on the market. Use values that are indirect refer to the life support services role of the natural environment, which are 'indirectly used'. In the MA report specifically compiled for wetlands, direct use values correspond to the MA's definition of provisioning and cultural services. Indirect use values correspond to MA's notion of regulating and supporting services. Provisioning, regulating and cultural services may all form part of the option values.

Option values reflect the value people place on a future ability to use the environment and thus the potential future benefits of goods and services. There is no full agreement about considering option and quasi-option values among use or non-use values. Non-use values include: existence values where the benefit results from knowledge that goods and service exist and will continue to exist, independently of any actual or prospective use by the individual; and bequest value, where the benefit is in ensuring that future generations will be able to inherit the same goods and services of the present generation.

The MA lists as commonly used valuation tools: replacement costs, effects on production, damage cost avoided, mitigative or avertive expenditures, hedonic pricing, travel costs, contingent valuation.

Assessing the TEV could be a useful tool for policymakers: determining the total flux of benefits that ecosystems generate and assessing the effects of specific projects or policies for better management.

2.3.2 Non-Market Valuation

Identifying the goods and services of an ecosystem and measuring their values are difficult because of a lack of ecological and economic information. Measuring the value of goods or services is fairly straightforward when they have a market-determined value. However, non-market values of ecosystem services are much more difficult to quantify because they do not have an established price.

There are several techniques that have been developed to determine economic values for non-market ecosystem services. These include: economic damages, the willingness of individuals to pay for goods and services or the willingness to accept compensation for losses. Those that focus on economic damages measure losses in productivity, expenditures to offset or replace natural capital services, or potential environment damages if a service is lost. The willingness to pay or accept compensation is determined by surveys or by observing people's behaviour or choices.

Avoided cost assesses the value for ecosystem services based on what society would have pay if ecosystems and their services are diminished and/or damaged. In other words the value is the avoided costs that would be incurred in the absence of those services. For example, flood control provided by wetlands in watersheds or water filtration provided by forested watersheds are very costly to replace with built infrastructure if they can be replaced. In addition, if these services are diminished due to environmental degradation or land use change potential there are also costs in terms of damages to human communities (e.g. flooding damages). Replacement cost is related to avoided cost but focuses on ecosystem services that could be replaced with human-made systems. For example, nutrient cycling waste treatment by wetlands can be replaced with costly treatment systems.

Net factor income valuation refers to valuation of services that provide for the enhancement of incomes. An example is water-quality improvements that increase commercial fisheries catches and incomes from the fishery. Travel cost is a measure of value based on what people pay to travel to experience or recreate in a natural area, the cost of which can reflect the implied value of the service. For example, recreation areas attract distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it. Hedonic pricing is the value reflected in the prices people will pay for associated goods or property. This method is often used to estimate how much additional property value is provided by proximity to natural areas or greenspace. For example, housing prices along the coastline tend to exceed the prices of inland homes because of their proximity to water recreation and coastal viewing. Contingent valuation is a method that determines values by posing hypothetical scenarios in surveys to individuals that involve some valuation of land-use alternatives. This method is often used for less tangible services like wildlife habitat or biodiversity. For example, a survey may be designed to determine how much would people would be willing to pay for increased conservation of beaches and shoreline in a certain community.

2.3.3 Benefit Transfer Approach

If local analysis cannot be undertaken, benefit values can be transferred from other studies. Benefit transfer (also called value transfer) identifies previously conducted studies that have assessed the value of an ecosystem service for a similar location, service and ecosystem. Benefit transfer (BT) involves the adaptation of existing valuation information or data to new policy contexts. In other words, the value determined for an ecosystem service from the original study site is applied to a new "policy" site.[6]

BT is becoming a practical way to inform decisions when primary data for a location is unavailable and primary valuation research is not possible given time and budgetary constraints. The number and quality of empirical economic valuation studies in the peer-reviewed literature is steadily increasing. This provides many single service and ecosystem-level studies, as well as the opportunity to assess average values from meta-analysis of multiple studies.

2.4 Purpose of Report

This report was commissioned by Environment Canada to review current work that has identified, quantified, and valued ecological goods and services (EGS) in Canada. The measurement of the qualitative and quantitative value of ecosystem services may be harnessed to allow for better environmental and economic management and inform better

6 Desvouges W.H., Johnson, F.R., and Banzhaf, H.S. 1998. Environmental Policy Analsys with Limited Information: Principles and Applications of the Transfer Method. Edward Elgar.Northhampton, MA, cited by Costanza, R., Wilson, M., Troy, A., Voinov, A., Liu, S., and D'Agostino, J. 2006. The Value of New Jersey's Ecosystem Services and Natural Capital. Gund Institute for Ecological Economics, University of Vermont and New Jersey Department of Environmental Protection, Trenton, New Jersey.

land use, environmental management, and policy decisions. The following sections summarize the state of current EGS work in Canada, including:

4) The ecological goods and services that have been studied, frameworks and methods used, and the outcomes/values reported as well as policy and planning implications.

5) The existing models used to map and value EGS, as well as the data sets and measurement information used to populate these models.

6) A summary table organized by EGS categories with regards to Environment Canada's responsibilities for water, air, soil, conservation and biodiversity and landscape management.

3 Ecological Goods and Services Studies in Canada

3.1 Regional Studies

This section provides a review of the regional studies of ecological goods and services (EGS) that have been undertaken within Canada. The values and outcomes reported by each study have been compiled in Annex 1. Most regional studies use land-cover spatial data and information to develop EGS values for regional decision-makers.

3.1.1 Counting Canada's Natural Capital

Anielski, M.A. and Wilson, S.J. 2005. *Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems*. The Pembina Institute and Canadian Boreal Initiative. Ottawa, Canada (2009 update).

3.1.1.1 Report Synopsis

Counting Canada's Natural Capital is based on a two-year study that identified and measured the economic value of ecological goods and services provided by Canada's boreal region. The authors developed the Boreal Ecosystem Wealth Accounting System (BEWAS) as a framework and tool to measure and report on the physical conditions and the economic value of the boreal region's natural capital and ecosystem services. The purpose of the BEWAS is to give Canadian decision makers a boreal natural capital "balance sheet" for assessing the sustainability, integrity, and full economic value of the boreal region. The balance sheet is broken down into three main accounting categories: natural capital accounts, land accounts, and ecosystem service accounts. The natural capital accounts include the qualitative and quantitative data on annual stocks and flows of the region's natural resources and ecosystem goods and services. The land accounts include the area for each land cover type, and the ecosystem service accounts include the amount and value of flows of non-market EGS provided by ecosystem type.

The study reports that the boreal region is Canada's largest ecoregion, covering over 58.5 percent of the country, or 584 million hectares (5.8 million square kilometres) from Newfoundland and Labrador to the Yukon. The estimated net market value of boreal natural capital extraction in the year 2002 was $50.9 billion. The net market value calculation is based on the contribution to Canada's GDP from boreal timber harvesting; mineral, oil, and gas extraction; and hydroelectric generation ($62.0 billion; or $106.15 per hectare of the boreal ecosystem land base) minus the estimated $11.1 billion in environmental costs (e.g., air pollution costs) and societal costs (e.g., government subsidies) associated with these industrial activities.

The estimated total non-market value of boreal ecosystem services in the year 2002 was $703 billion (or $1,204 per hectare of the boreal ecosystem land base). If accounted for, boreal ecosystem services would equate to 61 percent of the value of Canada's GDP in 2002. The ecosystem services with the highest economic value per year are (1) carbon storage by forests and wetlands—$582 billion (2) flood control and water filtering by peatlands—$77.0 billion; (3) flood control and water filtering and biodiversity provided by non-peatland wetlands—$33.7 billion; (4) pest control services by birds in the boreal forests—$5.4 billion; and (5) nature-related activities—$4.5 billion.

The total non-market value of boreal ecosystem services is 13.8 times greater than the net market value of boreal natural capital extraction.

3.1.1.2 Ecological Goods and Services Studied

The report examined market and non-market values for the region's natural capital. These values included forests, wetlands and peatlands, minerals and subsoil assets, and water resources. The costs of pollution and public subsidies are also reported. The costs included are: air pollution costs, government subsidies to mining sector, and oil and gas sector, and forest sector carbon emission costs.

The ecological goods and services that were assigned values include:

- climate regulation (carbon storage)
- water supply for municipal water use
- subsistence value for Aboriginal communities and households
- non-timber forest products (mushrooms, berries and wild rice)
- value of pest control in forests provided by birds
- passive value for wilderness conservation (willingness to pay)
- nature-based recreation
- flood control
- water filtration
- timber
- mining, oil and gas
- hydroelectric generation

3.1.1.3 Implications for Policy and Planning

The authors conclude that although the results are preliminary, the report reveals the importance of measuring the full range of ecological and social values of ecosystems for Canadians. Their accounts also show that the increasing pressures on boreal ecosystem integrity from human and industrial development could potentially threaten the future economic well-being of Canadians and global citizens.

The report suggests that Canadians consider:

- What level of development would be acceptable in order to minimize further fragmentation, loss of intact boreal ecosystems, and the degree of damage to ecosystem function?
- How much of the current intact boreal ecosystems should be protected from future development?

The report also suggests that all levels of government (federal, provincial, and municipal), working with industry and local communities, need to make a commitment to:

- Develop a system of natural capital accounting, such as the BEWAS, to guide land-use planning, resource management, and economic development policies. This accounting system would include a comprehensive and nationally coordinated inventory of boreal natural capital;
- Incorporate accounts of natural capital and ecological goods and services in national and provincial income accounts to guide economic, fiscal, and monetary policies; and,
- Provide full cost accounting of the social and environmental costs associated with natural capital development and total economic valuation of natural capital and ecosystem services.

The authors emphasize that the integration and development of the region's full economic value in policy and land-use decision-making is critical to protect the existing natural capital and ecosystem functions throughout the boreal region. Their recommendations identify important roles that federal and provincial governments, local representatives, industry, land-use planners, resource managers, scientists, Aboriginal communities, and conservation groups can play in partnership including:

- A comprehensive inventory of the area be completed and made publicly available. National, provincial, and local boreal region accounts should be developed including physical stock and flow accounts (inventory) of natural capital assets and ecosystem services. These accounts should include stock and flow information on the following: annual average growth rate of timber; fires (in terms of both area and volume lost); insect infestation; carbon storage by forests and wetlands; fisheries; and annual water flow rates in rivers and groundwater aquifers. Finally, these accounts should include an account of the state of ecosystem services in order to track or measure changes in ecosystem functionality and their respective service values.

- The identification, tracking and monitoring of specific effects of each type of human disturbance be identified, tracked, and monitored to determine the change in economic value of the boreal region's ecosystem services.

- That economic values for ecosystem services be further developed and adopted by all jurisdictions for resource and land-use planning, especially at the municipal and provincial levels where changes in land-use and resource planning are made.

- Based on the report's finding that the total non-market value of boreal ecosystem services is 13.8 times greater than the net market value of boreal natural capital extraction. There is an economic argument exists that supports a significant expansion of the network of protected areas in the boreal region, consistent with the Boreal Forest Conservation Framework's vision for sustaining the integrity of the region. Therefore, the report recommends that a policy be developed to expand the network of protected areas in the boreal region that would serve as an investment in the natural capital of the boreal region for the benefit of current and future generations of Canadians and global citizens.

- The authors also recommend that to ensure the optimum value of ecosystem services is recognized and conserved, resource management and land-use decisions need to account for impacts (i.e., costs and benefits) on ecosystem services and the overall state of the region's natural capital. The Boreal Forest Conservation Framework's vision of conservation-based resource management practices should be implemented in order to minimize costs and maximize local ecological values.

3.1.2 The Real Wealth of the Mackenzie Region

Anielski, M.A. and Wilson, S.J. 2007. *The Real Wealth of the Mackenzie Region: Assessing the Natural Capital Values of a Northern Boreal Ecosystem*. Canadian Boreal Initiative. Ottawa, Canada (2009 update).

3.1.2.1 Report Synopsis

The Real Wealth of the Mackenzie Region report constructed a natural capital account for the Mackenzie watershed including a total economic valuation of the market and non-market benefits of the watershed's natural capital. The study was the first watershed-based natural capital review in Canada.

The Mackenzie watershed spans 1.7 million square kilometers (170 million hectares). The market value of the Mackenzie watershed, assessed as the region's GDP, was estimated at $41.9 billion per year, an average of $245 per hectare. The non-market value of the watershed, assessed as the potential value of 17 ecosystem services produced by the region, was estimated at $570.6 billion per year, an average of $3,426 per hectare.

The ecological goods and services provided by nature (e.g. carbon storage, water filtration, water supply) in the Mackenzie contribute over 13.5 times more societal economic value than the GDP generated by natural capital extraction industries. The industrial footprint in the region covers 25.6 million hectares and the estimated cost of natural capital degradation from development is likely to be in the billions of dollars.

The report does not suggest that natural capital extraction should cease, but rather that there be a more prudent approach to future natural capital stewardship, so that valuable ecosystem services can be maintained while meeting human needs and economic development objectives. The most valuable ecosystem services was the carbon storage by forests, peatlands, wetlands and tundra valued at an estimated $339 billion in 2005, or 60 percent of the total estimated non-market value of ecosystem services.

3.1.2.2 Ecological Goods & Services Studied

This report includes a physical account of the natural capital in the Mackenzie watershed using spatial satellite imagery of land cover to estimate the area of each land cover type as well as linear disturbance by industrial development. In addition, the market and non-market values provided by the watershed's natural capital. The non-market ecosystem services were reported as the Ecosystem Service Product (ESP) for each land cover type for 17 possible ecosystem functions:

- atmospheric regulation
- climate regulation
- disturbance avoidance
- water stabilization and regulation
- water supply
- erosion control and sediment retention
- soil formation
- nutrient cycling
- waste treatment
- pollination
- biological control
- habitat/refugia
- food production
- raw materials
- genetic materials
- recreation
- culture

3.1.2.3 Implications for Policy and Planning

The Canadian Boreal Initiative (CBI) commissioned this study to help decision makers — federal, territorial, provincial and First Nations governments — make stewardship decisions that balance broader ecosystem and cultural values with sustainable economic growth. The study's primary goal was to construct a natural capital account for the Mackenzie watershed, including a total economic valuation of the market and non-market benefits of the watershed's natural capital.

The authors conclude that the results demonstrate that the natural capital of the Mackenzie Region contributes significantly to the cultural, social and economic health and well-being of all Canadians; and, that the full wealth of the Mackenzie is significantly discounted when measured only in terms of market value. They suggest that when the economic value of our natural capital assets – clean air, clean water, and healthy, productive landscapes— is not considered or accounted for, then policy and planning is not accounting for important national assets.

The report also concludes that further work is required to develop natural capital values and to accurately track and measure changes in ecosystem values over time. The authors recommend:

- The establishment of comprehensive and on-going national, provincial, territorial and regional inventories of natural capital values that are maintained over time and made publicly available;
- Investment in research to establish the impact of human development and land use change on natural capital, including active monitoring of the pace, scale and extent of anthropogenic changes in the landscape to determine the impacts on the economic value of ecosystem services.
- The development and implementation of standardized methods for natural capital accounting at the national level to guide resource and land-use planning decisions.
- Immediate action by decision makers to safeguard natural capital values, such as those related to water quantity and quality and carbon storage and sequestration, in Canada's boreal region for the benefit of current and future generations. Such measures can be effectively implemented through land-use planning in advance of major development and through an expanded network of parks and protected areas. They refer to the balanced approach in the Dehcho Land Use Plan as an example of how this could be achieved by drawing on both science and traditional knowledge to guide development decisions.
- That innovative mechanisms be explored to integrate natural capital values into market-value economics and sustainable development practices. They refer to regulatory and voluntary carbon trading regimes as examples of efforts to ensure that climate-related costs are effectively integrated into market decisions. Similar regimes should be considered for clean water and other natural capital assets to ensure that economic activities reflect the full costs and benefits to society.

3.1.3 A Valuation of Ecological Services in the Great Lakes Basin Ecosystem to Sustain Healthy Communities and a Dynamic Economy

Krantzberg, G., and de Boer, C. 2006. *A Valuation of Ecological Services in the Great Lakes Basin Ecosystem to Sustain Healthy Communities and a Dynamic Economy*. Dafasco Centre for Engineering and Public Policy. McMaster University. Hamilton, Ontario. (prepared for the Ontario Ministry of Natural Resources.

3.1.3.1 Report Synopsis

The economic value of the Great Lakes to the health of people, communities and the economy in Ontario is examined in this article. Over 8 million Canadian and 35 million US residents live, work and recreate in or by the waters of the Great Lakes basin. The Great Lakes is the largest system of fresh, surface water in the world, and one of the largest freshwater fisheries in the world. The Great Lakes basin covers a total area of 244,000 square kilometers and contains 22.8 trillion litres of water, of which only one per cent is renewable each year. The lakes are particularly important for water supply as 31 per cent of Canadian live in the basin and one in three Canadians depend on the Great Lakes for their water.

The study was designed to provide a credible assessment of the contributions made by the Great Lakes to the local, provincial, and national economy of Canada. The major uses of the Great Lakes are identified and their benefits where possible are ascribed.

3.1.3.2 EGS Studied

The economic values of the Great Lakes reported include:

- commercial fishing and aquaculture
- transportation of bulk goods
- recreational fishing, boating and beach visits
- wetlands and biodiversity

3.1.3.3 Policy/Planning Implications

The author frames the study on the importance of the Great Lakes Water Quality Agreement (GLWQA) between Canada and the U.S, and the need to review it. Her message is to ensure that the responsibilities and objectives are achieved. The message to government is that they identify the economic values associated with the natural assets of the Great Lakes as policies and programs for protecting the environment in the Great Lakes Region are developed. “Sustainable management policies for the future will be impossible to formulate without an understanding of how management decisions and ongoing transformation in the Great Lakes region affect ecological and therefore economic and social well-being”

3.1.4 Nature Counts: Valuing Southern Ontario’s Natural Heritage

Canadian Urban Institute. 2006. *Nature Counts: Valuing Southern Ontario’s Natural Heritage*. Toronto, Canada (prepared for the Ministry of Natural Resources – Natural Space Program).

3.1.4.1 Report Synopsis

The Natural Spaces program is an advisory group of conservation representatives appointed by the Ontario Minister of Natural Resources that was set up in 2005. The mandate of Natural Spaces is to encourage greater stewardship and conservation of southern Ontario's natural areas by providing the strategic focus and tools necessary to enhance the green infrastructure that helps sustain its communities. The Alliance identified the need for a better understanding of the socioeconomic benefits of southern Ontario's natural areas, and therefore, commissioned a study to review the socio-economic benefits provided by natural and rural areas as a first step toward promoting and raising awareness of these benefits. This report examines the recent rural demographic and economic changes, human health, social benefits and the importance of natural assets in southern Ontario.

Southern Ontario is the area of Ontario south of French River and Algonquin Park. This area was selected for this study because of concerns about rapid population growth, urban sprawl and the sustainability of ecosystems in the region. The authors report that high rates of urban growth and development, coupled with the historic changes in natural land cover stand to threaten the viability of southern Ontario's natural systems. There has been a 33 percent increase in population since 1986, and the provincial government forecasts growth over the next 25 years to continue at much the same rate, which will bring Ontario's population in 2031 to between 14.5 and 18 million.

3.1.4.2 EGS Studied

This study considered the economic benefits of natural heritage in Southern Ontario in terms of:

- private land forestry,
- resource-based tourism
- agriculture, and
- alternative and renewable energy benefits for landowners.

3.1.4.3 Policy/Planning Implications

The primary audiences for this discussion paper are municipal and provincial decision makers and stewardship and conservation professionals, as well as interested members of the public. The context given for the report is the rapid increase in population predicted for Southern Ontario. According to the report, Southern Ontario is poised to experience rapid increases in population over the next 20 years, with urbanization and population growth having noticeable impacts on air, water and ecosystem quality. The report suggests that these trends provide opportunities for policy makers, municipal and community leaders to work toward an integrated vision that balances growth with greenspace conservation, and which uses greenspace as an economic attractor for growth.

The authors suggest it is important to:

- Provide municipalities with tools to identify major natural heritage systems for protection and restoration as a foundation for local conservation and stewardship activities;
- Build on work of urban and near urban conservation authorities and municipalities to better engage newcomers to southern Ontario in conservation and stewardship in their communities; and,

- Explore farm and non-farm landowner connections and opportunities of mutual benefit and engage both sectors in stewardship of natural heritage systems and preservation of local agricultural economies.

At the municipal level, the report suggests it is necessary to:

- Monitor and support emerging shifts in southern Ontario's rural agricultural economies toward new crops (e.g. biomass and medicinals) and other niche-market agriculture thattakes advantage of growing urban markets.
- Promote eco-tourism and agri-tourism - the combination of agriculture, natural areas and tourism - in local economic development strategies as well as other approaches that capitalize on natural assets.
- In areas of declining population, explore with municipalities, economic development and stewardship organizations, the opportunities of an emerging minor "rural rebound" of retired baby boomers on local economies, local recreational services and volunteer stewardship.
- Support southern Ontario forestry with mechanisms for identifying opportunities to expand forests and better utilize marginal lands; engage landowners with incentives, tools and extension services; increase the availability of native tree seedlings and ensure the right species are planted in the right places.
- Promote the potential for alternative energy to enhance rural economic viability as well as environmental quality.

The report recommends that a better understanding of the links between EGS and human health, such as health care costs due to poor air quality, is needed. Steps to do this include:

- Exploring linkages between individual well-being, reduced health care costs, improved physical, mental and emotional health and southern Ontario's greenspace.
- Exploring how increasing urban densities require careful planning for sufficient "green services" to serve a larger population – parks, trails, sports fields, urban forests and natural areas provide an essential human service.

The report also concludes that supporting green infrastructure – the natural infrastrucutre that provide ecological services such as water supply, water regulation, flood control and water filtering – for human communities - will prove a wise investment in the competitiveness challenges of the twenty-first century. To continue to build the economic case for conservation, provincial and municipal leaders could:

- Explore and document low-cost "green infrastructure" alternatives to new or expande water and sewage treatment facilities; use of storm ponds and maintenance of wetlands and forests as drought and flood management systems.
- Develop tools for municipalities to identify opportunities to use natural heritage to maximize property values and property assessment through careful site planning, and to minimize servicing costs.
- Develop tools for municipalities to document the value of natural heritage as a foundation for their local economies, and approaches to maximize community economic development strategies.

3.1.5 The Economic Significance of Nature-Related Activities in Canada

Duwors, E. et al. 1999. *The Importance of Nature to Canadians: The Economic Significance of Nature-Related Activities*. Environmental Economics Branch. Environment Canada. Ottawa, Canada.

3.1.5.1 Report Synopsis

This report presents results on the economic significance of nature-related activities based on the findings of the national Survey on the Importance of Nature to Canadians. A partnership of 16 agencies in the governments of Canada, the 10 provinces, and the Yukon sponsored the Nature Survey. It was conducted by Statistics Canada among a representative sample of approximately 87,000 Canadians, 15 years of age and over. The report also presents results on spending by U.S. visitors to Canada for nature-related activities derived from a U.S. survey.

The surveys show that Canadian residents and U.S. visitors spent $11.7 billion on nature-related activities in Canada during 1996. The report examines the economic impacts of these expenditures for Canada, the provinces and the Yukon, in terms of contributions to GDP, jobs sustained, and tax revenues. It also reports the economic value of nature-related activities to Canadians.

3.1.5.2 Ecological Goods and Services Studied

- Outdoor activities
- Wildlife viewing
- Recreational fishing
- Hunting

3.1.5.3 Implications for Policy and Planning

The authors state that strategic knowledge of the economic significance of Canada's natural assets is important for influencing decision-makers to factor economic considerations into environmental regulations and policies. It is also important for encouraging decision-makers to incorporate environmental considerations into the development and implementation of economic policies.

The survey's results demonstrate the magnitude of the benefits that the enjoyment of Canada's natural wealth contributes to the people and the economy. The report concludes that information on the economic benefits provided by nature-related activities could serve as a powerful tool to influence decision-makers to achieve sustainable development in at least three ways - namely, by

- developing new economic indicators of sustainability to improve decision-making,

- enhancing public recognition of the important economic contributions of Canada's ecosystems and biodiversity in the national income accounts, and
- helping to demonstrate the significant returns to investments in actions to sustain Canada's natural assets by providing measures of the economic benefits that may be lost if these assets are degraded.

The report also concludes that periodic updating of the Survey on the Importance of Nature to Canadians is needed to contribute to valuing Canada's natural wealth and to monitor economic indicators of the sustainability of these assets in the coming years.

3.2 Watershed, Wetland and Water Value Studies

This section includes studies that have reported on EGS provided by watersheds including wetland and water ecological services valuation. The reported values and outcomes are provided in Section 2 of Annex 1.

3.2.1 *The Value of Natural Capital in Settled Areas of Canada*

Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Centre for Public Policy Research. Simon Fraser University. Vancouver, British Columbia. (Prepared for Ducks Unlimited Canada and The Nature Conservancy of Canada).

3.2.1.1 Report Synopsis

This report identifies and values the ecological goods and services provided by the natural capital within settled areas using case studies from various regions across Canada. According to the author, the case studies in this paper illustrate that governments may be making inefficient choices in allocating land to uses that destroy or degrade natural capital.

This report presents four 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 good data measuring the physical amount of natural capital is lacking. These fundamental data are necessary for estimating the value of conserving natural capital and are needed to help make informed public policies about land use.

The author reports that agricultural lands 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 (i.e. conservation cover).

The study reports on four case studies:

- The Lower Fraser Valley, which encompasses approximately 16,225 square kilometres 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).
- The Grand River watershed is the largest in southern Ontario covering approximately 6,800 km2, 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 Upper Assiniboine River Basin (UARB) is a region dependent predominately on agriculture. The UARB consists of 21,000 km2 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 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. Potato production, shell and fin fishing, recreation and cottaging are key activities in the area.

3.2.1.2 EGS Studied

In the case of the Lower Fraser Valley, a review of all relevant wetland and forest ecosystem goods and services valuation studies are reported. Most of these values are benefit values transferred from other EGS valuation studies to provide estimated values for the region. Values are reported for waste treatment services, flood protection, recreational use, non-timber forest products, carbon sequestration, wildlife viewing, hunting and fishing, as well as global values for total EGS for estuaries, lakes and rivers, temperate forests and grasslands. The latter values are transferred from the Costanza et al. (1997) paper on the global value of nature's services. See Annex 1for the EGS values provided.

The agricultural land case studies report on the value of conserving or restoring permanent vegetative cover and ecologically sound farming practices are assessed in terms of:

- Improved water quality and decreased water treatment costs;
- Lower dredging costs to remove sediment from water conveyance and storage infrastructure;
- Increased recreational opportunities such as fishing, swimming, hunting and wildlife viewing;
- Decreased net greenhouse gas (GHG) emissions;
- Mitigation of flooding; and
- Protection and enhancement of ecological services.

3.2.1.3 Policy/Planning Implications

The author states that case studies in this report illustrate that governments may be making inefficient choices in land use decisions that result in the degradation and/or loss of natural capital. She concludes that 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. The report recommends that:

- 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.
- An increase in efforts to measure and quantify the services of nature to assist government and individuals to make more efficient land use decisions is needed. 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.

The report does not propose specific policies or programs for the protection of natural capital, however, the author identifies the specific types of action that governments should take including:

- Providing essential data on the physical quantities and attributes of natural capital and their changes over time.
- Assisting in better decision making by coordinating and funding efforts to measure and value natural capital. 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.
- 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 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) to coordinate efforts to conserve and restore natural capital.

3.2.2 *The Impacts of Wetland Loss: Broughton's Creek Watershed*

Ducks Unlimited Canada. 2008. *Impacts of Wetland Loss: Broughton's Creek Watershed, Southwest Manitoba*. Ducks Unlimited Canada and University of Guelph.

3.2.2.1 Report Synopsis

This report is the first phase of a multi-phase research project to determine the impacts of wetland loss and associated drainage in the Broughton's Creek watershed located in southwestern Manitoba. The area was selected because the land use and wetland loss trends are representative of other agricultural watersheds across the Prairie Pothole region of Canada. This region is a priority area for waterfowl and is critical to North America's waterfowl populations.

3.2.2.2 EGS studied

The first step of the project was to determine the amount of wetland loss and drainage patterns that occurred between 1968 and 2005. The study found that 5,921 wetland basins or 70 per cent of the total number of wetland in the watershed have been degraded or totally lost due to drainage.

The second step focused on the development of a hydrologic model to evaluate environmental impacts of the losses in wetlands.

3.2.2.3 Planning/Policy Implications

Wetlands collect and store water from the surrounding landscape during rain or snowmelt. Wetlands are able to filter sediments and nutrients before slowly returning water to the water cycle. When wetlands are drained, or even partially drained, the local drainage area is connected to downstream flows. Although this study focuses on Manitoba, the cumulative impacts of wetland drainage will have negative impacts anywhere in Canada.

The authors report that the root cause for this continued loss of wetlands is that agricultural producers are faced with market forces, policy signals and economic incentives to drain wetlands rather than to conserve them. DUC's research has confirmed that society is the primary benefactor of wetlands. However, agricultural producers alone are burdened with costs to retain them.

The researchers recommend that wetlands need to be made a public policy issue with the objective of developing an integrated and comprehensive wetland policy that effectively stops wetland loss. The report recommends proactive and comprehensive wetland policies across Canada that provide incentive-based programming for producers complimented by legislated protection, extension, tax credits, public outreach, removal of barriers to adoption and other tools. This will create the necessary paradigm shift to ensure that wetlands remain functioning.

3.2.3 Water Quantity and Quality Benefits from Wetland Conservation and Restoration in the Broughton's Creek Watershed

Yang, W., Wang, X., Gabor, S., Boychuk, L, and Badiou, P. 2008. *Water Quantity and Quality Benefits from Wetland Conservation and Restoration in the Broughton's Creek Watershed*. Ducks Unlimited Canada. Manitoba, Canada.

3.2.3.1 Report Synopsis

The purpose of this study was to develop and use a prototype modeling system to evaluate the environmental benefits of prairie wetlands at a watershed scale. The specific objectives were to: 1) use a "hydrologic equivalent wetland (HEW)" concept in the Soil and Water Assessment Tool (SWAT) to develop a prototype modeling system; 2) calibrate and validate the SWAT-based modeling system for the Broughton's Creek watershed; and 3) use the calibrated modeling system to assess the prospective wetland conservation and restoration scenarios in the Broughton's Creek watershed.

3.2.3.2 EGS studied

Streamflows from the Oak River at Shoal Lake were transferred to approximate the streamflows at the outlet of the Broughton's Creek watershed, where observed data are unavailable. The transferred data were used to validate the SWAT-based modeling system.

The SWAT-based modeling system was applied to examine the effects of wetland conservation and restoration in the Broughton's Creek watershed. Changes in peak discharge at the watershed outlet, sediment loading, and total phosphorus and total nitrogen at the watershed outlet were examined within six scenarios having wetland areas ranging from 2,379 ha to 2,998 ha. The results show the benefits of wetland conservation and restoration.

3.2.3.3 Planning/Policy Implications

This study's results provide pertinent data that can be used to recommend wetland conservation and restoration in terms of the ecosystem services that were measured. The researchers report that restoring wetlands in the watersheds drained by the major tributaries of the Red River of the North is likely to alleviate the eutrophication of Lake Winnipeg.

3.2.4 Valuing Wetland Ecosystem Services in the Credit River Watershed, Ontario: Phase 1 Report (Draft report; not yet released)

Hotte, N., Kennedy, M., and Lantz, V. 2009. *Valuing Wetland Ecosystem Services in the Credit River Watershed, Ontario: Phase 1 Report*. (March 2009 draft). The Pembina Institute. Drayton Valley, Alberta.

3.2.4.1 Report Synopsis

This is a first phase report that is currently in draft form. It is part of a two-phase research project focusing on valuing wetland ecosystem services in the Credit River Watershed, in southern Ontario. The report reviews peer-reviewed literature on the human impacts on wetlands and their ability to provide ecosystem services. They report that severe disturbance of an aquatic ecosystem can lead to an abrupt and substantial disruption in the supply of one or more ecological services. For example, at a certain threshold ecological services will decline. It is these thresholds that are difficult to measure when evaluating EGS.

A summary of the literature in this report focuses on: (i) identifying/quantifying wetland ecosystem services; (ii) assessing the impact that human activities/actions have on these services; and (iii) estimating the economic value provided by these services. The authors are in the process of summarizing the biophysical and socioeconomic data that has been collected for wetlands in the Credit River watershed in order to determine the methods that will be employed to assess the value of ecosystem services provided by the wetlands in Phase 2.

3.2.4.2 Planning/Policy Implications

Because the report is work currently in progress, planning or policy recommendations have yet to be reported.

3.2.5 Natural Capital – An Economic Valuation of Water as an Input to the Alberta Economy (Draft report; not yet released)

Gardner Pinfold Consulting Economists Limited. *Natural Capital – An Economic Valuation of Water as an Input to the Alberta Economy.* Prepared for the Government of Alberta and Government of Canada.

3.2.5.1 Report Synopsis

This study examines the economic value of water as a part of natural capital. Natural capital is the stock of natural resources and environmental assets that includes water, soils, air , flora, fauna, minerals and other natural resources which have a value because they provide an on-going stream of economic services. In this evaluation, the process was to identify water-using activities, select an appropriate valuation method from *Monitoring the Value of Natural Capital: Water* (Gardner Pinfold study conducted for Environment Canada and Statistics Canada in 2002).

3.2.5.2 EGS Studied

Commercial and institutional water use
Industrial water use
Oil and gas and mining water use
Hydro power generation water use
Thermal power water use
Recreation fishing
Passive uses (bequest, option and existence values)
Ecosystem services

3.2.5.3 Planning/Policy Implications

The authors provide a number of recommendations for data and methodological issues that should be addressed in future water valuation work for the South Saskatchewan River Basin and for Alberta as a whole including a need for:

- data on the actual amount of water used for irrigating various crops, and information on private irrigators is limited..
- improved data on fisheries and aquaculture.
- current data on turbine water flows/water use (i.e hydroelectricity).
- quantitative data or estimates of the amount of participation in water-related recreational activities, and estimates of the value that individuals attach to participating in recreational activities, or information from which such estimates could be made.
- readily available design and cost information on alternative ways to handle treated wastewater other than using rivers and streams as a disposal service.

One objective of this study was to test the methodology outlined in the 2002 NCV report. The work undertaken in this study has identified a number of issues for consideration in future work including:

- avoid double counting by ensuring that the ‘services’ being valued are actually outputs rather than inputs. For example, the ecosystem services provided by “habitat” are opportunities for wildlife viewing, and existence values, both of which are captured under recreation and passive uses.

- ensure that ecosystem service inputs are ‘added up’ consistently, and that the ecosystem being assessed is clearly defined in terms of its inputs and outputs.

- water flows versus quality: flows,contribute directly to quality, but more importantly, both flow and quality contribute to use and non-use values. Therefore estimated values for water quality are contingent on a certain level of flows and vice-versa..

- improving the reliability of benefit transfer: Most candidate studies for benefit transfer include a number of socio-economic and demographic variables for which there are no data for the target population (e.g. participation in conservation organizations). It is likely that proxy variables could be created from existing data to increase the reliability of the benefit transfer estimates for some of these studies. However, it would be useful to test for the error associated with omitting these variables or using averages for benefit transfer estimates before recommending this approach in general.

3.2.6 An Ecosystem Services Assessment of the Lake Winnipeg Watershed. Phase 1 Report – Southern Manitoba Analysis

Voora, V., and Venema, H.D. 2008. *An Ecosystem Services Assessment of the Lake Winnipeg Watershed. Phase 1 Report – Southern Manitoba Analysis*. International Institute for Sustainable Development. Winnipeg, Manitoba.

3.2.6.1 Report Synopsis

This report was commissioned by Environment Canada to assess the ecosystem services provided by the current and pre-settlement distribution of southern Manitoba’s environmental assets. Lake Winnipeg is the 10th largest freshwater lake globally and its watershed drains an extensive 984,000 km^2 multi-jurisdictional landscape consisting of parts of Alberta, Saskatchewan, Manitoba, Northwestern Ontario, Minnesota, North Dakota and South Dakota. The watershed is home to 5.5 million people (80 per cent of whom are urban dwellers) and 20 million livestock.

Lake Winnipeg is the most eutrophic of the world’s largest freshwater lakes. The excessive algae growth is caused by high phosphorous and nitrogen loads resulting from human activities in the watershed. The watershed contains about 90 per cent of the Canadian Prairies’ agricultural land. The authors examine the study area’s potential to deliver billions of dollars more a year in ecosystem services through the restoration of these natural environments.

3.2.6.2 EGS Studied

Seventeen ecosystem services, which are commonly used in the literature, were examined for each land cover type to carry out the valuation study (Anielski & Wilson, 2007; Costanza et al., 1997; R. S. de Groot, Wilson, & Boumans, 2002). The ecosystem services investigated included water quantity and quality, climate change, biodiversity, material benefits, social well-being and environmental integrity services.

Ecosystem service value (ESV) ranges were compiled for each land cover type based on four relevant Canadian valuation studies (Anielski & Wilson, 2005, 2007; Kulshreshtha & Pearson, 2006; Olewiler, 2004). The ESV ranges were multiplied by the respective land cover areas mapped for each landscape.

3.2.6.3 Planning/Policy Implications

The authors report methodological shortfalls in this assessment including the pre-settlement reconstruction approach and the limitations of economically valuing ecosystem services. Current economic valuation methodologies do not accurately capture the value of ecosystem services. In addition, transferring ecosystem service valuation information from one context to another introduces error as no two contexts are similar. In this study, the ESV ranges were derived by aggregating total, average and marginal values which does not lend itself well for decision making based on conventional economics as they cannot be compared to marginal values. Consequently, decision making based on marginal and aggregated values may lead to more sustainable outcomes. Despite the limitations of economically valuing ecosystem services, the report concludes that it is important to draw attention to the valuable services provided by natural environments.

3.2.7 Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services

Wilson, S.J. 2008. *Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services*. Lake Simcoe Region Conservation Authority and the Greenbelt Foundation. Ontario, Canada.

3.2.7.1 Report Synopsis

Lake Simcoe is located in southern Ontario, within an hour's drive from Toronto. Aside from the Great Lakes, Lake Simcoe is the largest inland lake in southern Ontario with a surface area of 722 square kilometres. The total Lake Simcoe watershed area is 3,307 square kilometers, with 2,502 square kilometres in total land area (i.e. the area of land that drains into the lake).

This study quantifies the natural capital value of the ecosystem goods and services provided by the Lake Simcoe's watershed. It is the first study of EGS in a watershed in southern Ontario. The overall value for the EGS reported in this study is $975 million per year. The most highly valued natural assets are forests and wetlands, worth $319 and $435 million per year, respectively. The high value for wetlands reflects the many important services such as water regulation, water filtration, flood control, waste treatment, recreation and wildlife habitat. Forests high value reflects the importance of services such as water filtration, carbon storage, habitat for pollinators and recreation.

3.2.7.2 EGS studied

Ecological goods and services were ascribed by land cover and land use type. Values were estimated for the following non-market EGS, where possible:

- air quality
- climate regulation
- flood control
- water regulation
- water filtration
- water supply
- erosion control and sediment retention
- soil formation
- nutrient cycling
- waste treatment
- pollination
- seed dispersal
- habitat
- recreation, and
- cultural aesthetic values.

3.2.7.3 Policy/planning Implications

The report was commissioned in concert with a commitment by the government of Ontario to limit ecological damage to the watershed in 2008. One of the goals was to highlight the importance and urgency of protecting the Lake Simcoe watershed for residents and surrounding communities. For example, the study states that if residents lost the services provided by the watershed they would have to pay for the services that can be replaced by manmade infrastructure as well as risk losing many of the benefits permanently.

The report was also geared to provide information for a watershed plan that the Ontario government plan is developing. In addition, the ecosystem values in this report are recommended as a useful tool for other regions to determine the hidden wealth of their respective ecological systems for planning for healthy and sustainable communities.
In terms of land use planning, this report suggests that ecosystem values can be a useful tool for determining the potential changes in ecosystem services due to policy and land use decisions. "For example, land use planning at the watershed scale can utilize the

physical supply of services (e.g. tonnes of carbon stored or nutrients absorbed) and the service values (e.g. dollars per hectare) to assess the loss of services and the cost due to changes in the natural cover of the watershed to an alternate use." The author notes that it is important that ecosystem values be considered in conjunction with other sources of information, such as biophysical and non-monetary ecological information.

Recommendations from the report:

- The provincial government should include valuation of the area's ecosystem goods and services as they develop and implement the Lake Simcoe Protection Act and Plan. The Plan's designated policies should ensure meaningful protection of the entire watershed's scope of the natural heritage features.

- Municipal governments and councils in the Lake Simcoe watershed should consider integration of ecosystem goods and services and their value into the development of growth strategies, and as part of their land use planning and policy development decision making.

- The provincial government, associated municipal governments, and conservation authorities should examine creating an integrated natural capital account system for the Lake Simcoe watershed. That is, establish accounts that document the quantity and quality of land, ecosystems and natural resources consistently over time. This information would assist in making decisions about development and permitted land-uses.

3.3 Protected Area Studies

3.3.1 Pimachiowin Aki World Heritage Project Area Ecosystem Services Valuation Assessment

Voora, V. and Barg, S. 2008. *Pimachiowin Aki World Heritage Project Area Ecosystem Services Valuation Assessment*. International Institute for Sustainable Development. Winnipeg, Manitoba.

3.3.1.1 Report Synopsis

This report is an ecosystem services valuation assessment for the Pimachiowin Aki World Heritage Project. As an UNESCO World Heritage nomination, this project area needs to be backed up with considerable research on the natural and cultural values of the area. This study is one of several studies supporting the nomination bid.

The study found that ecosystem goods and services have an annual economic value of Cdn$121 to $131 million in the study area. The services with the greatest value are fishing (at $35 million/year), pure water ($32 million/year) and carbon sequestration (between $12 and $21 million/year). This estimate is conservative, as a number of the ecosystem services identified were not valued due to a lack of information.

3.3.1.2 EGS studied

The ecosystem services were examined by grouping them into four main areas according to the categories developed by the Millennium Ecosystem Assessment:

- Provisioning: Hunting, fishing, wild rice harvesting, clean water supply, trapping, medicinal plants, water for electricity.

- Regulating: Carbon sequestration (the value of the carbon dioxide taken out of the air and stored by trees and plants) air filtration, water treatment, erosion control, flood prevention, pest control.

- Cultural: Recreation (camping and canoeing), spiritual and religious benefits, cultural heritage benefits and education.

- Supporting: Plant pollination, biodiversity and natural habitats, soil and rock formation.

The following table provides a list and description of the ecosystem services that were identified for the study area under the above categories.

3.3.1.3 Case Study Methodology

A spatially based ecosystem services valuation approach was used. Measurement of the spatial areas of various different land and water cover types was the basis for an estimate of the types and amounts of ecosystem services that could potentially flow from them. In this study, ecosystem service economic values were derived for people living within and outside the site and were aggregated to provide an overall economic value for the site.

A land cover map was compiled to determine the spatial extents of the various land covers that make up the Pimachiowin Aki site. GIS land cover data was acquired from Natural Resource Canada to create a comprehensive land cover map of the area. The data, which were classified into 20 land cover classes, were derived from 2000 Landsat imagery with a 25-metre resolution.

Ecosystem services were identified by land cover type and grouped into provisioning, regulating, cultural and supporting services to structure the analysis. This categorization was done in accordance with the Millennium Ecosystem Assessment framework. Emphasis was placed on identifying the ecosystem services relevant to the communities living within the site but services that were of regional and global relevance were also included. For instance, food provisions provided by hunting and fishing, as well as spiritual and educational opportunities, were ecosystem services identified as being directly relevant to local communities. Water treatment and carbon sequestration were identified as being services that have economic value of regional and global relevance. The ecosystem services that did not have economic values were discussed qualitatively.

The ecosystem services provided by the site were quantified and valued where possible based on relevant data obtained from a number of studies that have either been conducted in parts of the study area or in similar locations. For instance, the total populations of furbearing animals caught for trapping was estimated based on studies conducted within Ecoregion 90 (ER90), which encompasses a portion of the area.

The following paragraphs provide an overview of the types of values transferred for the assessment of the study area's ecosystem services:

1) Food provision
The food provision services were estimated based on the hunting, fishing and wild rice harvesting activities of ER90. The value for hunting was estimated by calculating expenditures (hunting licences, supplies, food, hunting and repair gear, lodging and travel) and wild meat replacement costs. Hunting expenditure information was obtained from a socio-economic study conducted in ER90, which found that residents spend CDN$613 per animal and non-residents spend CDN$3,000 per bear, CDN$2,500 per deer and CDN$5,000 per moose. Wild meat replacement cost was estimated from bear, moose and deer harvest information from ER90, average animal weights, meat-to-total-weight ratios and farmed wild animal meat market values The harvesting information dated mid-1990s to present was modified and applied to the study area. The accuracy of the estimates could be improved with the use of more up-to-date harvest information.

The value of fishing was assessed using:

- The total landed value of fish harvested from Lake Winnipeg by Poplar River/Big Black/Neginnan's.
- The recreational fishing economic value provided by the area was calculated by estimating fishing expenditures (fishing licenses, supplies, food, fishing and repair gear, lodging and travel) and catch replacement costs for resident and non-resident populations.
    - Fishing expenditure information was obtained from a socio-economic study conducted in ER90 that found that residents spent CDN$16.44 million per year and non-residents spent CDN$4.34 million per year in 1995.
    - Catch replacement costs were estimated based on the number, species, average weights and market values of fish caught in ER90 in 1995. The catch distribution between resident and non-resident populations was determined from respective angler days compiled for ER90 in 1995.
    - Average fish weights and their market values were estimated based on information from Wikipedia and the Manitoba Conservation 1999–2000 Annual Report. The market values were adjusted for inflation to 1995 so they could be multiplied with the 1995 harvest data, and the total economic values where then adjusted for inflation to 2007.

Wild rice harvest information was collected from ER90 and historical annual averages were obtained from local processing companies. They reported total harvest yields ranging from 250,000 to 600,000 pounds over the years, representing an annual revenue of between CDN$175,000 and $425,000.

Water supply was estimated based on studies conducted in Manitoba to determine the willingness to pay to conserve and protect water. The study determined that the average willingness to pay for Manitobans was approximately CDN$28.13/household/month (Rollins et al., 1997). Adjusting the figure for inflation gives a mean willingness to pay CDN$421.95/household/year. Another study estimated that Winnipeg residents would be willing to pay CDN$115.20/household/year in 1999 to improve their drinking water quality (McComb, 2002). Adjusting this figure for inflation (CDN$138.30/household/year) and applying it to the 921 households in the study area (Statistics Canada, 2006), a total willingness to pay of CDN$130,000 per year for quality drinking water was estimated.

Water supply services were also estimated based on volume of flow. Values were extracted from a study on the economic value of the Assiniboine Aquifer water supply located in southwestern Manitoba (Kulshreshtha, 1994). Using volumetric discharge information from the major rivers of the study area, the authors estimated a total potential water supply economic value by adjusting the economic values reported in Kulshreshtha (1994) for inflation (CDN$40,000/$m^3$ to $800,000/$m^3$) and applying these figures to the volumetric discharge of the main rivers of ER90. The potential economic value was reported between CDN$0.27 to $5.55 billion/year.

3.3.1.4 Strengths and Weaknesses

Most of the values derived for the ecosystem services evaluated were estimated based on valuation studies that have been conducted in other areas. Transferring valuation information from existing studies to the study site invariably introduces errors in the analysis. This was minimized by using valuation studies that were conducted in similar environments as the study area. In addition, the values transferred were adjusted for inflation and currency differences. A brief discussion is included on the relevance of the valuation transfer for each economic value derived in the assessment. In several cases the economic values calculated were not included in the overall results due to the context differences between the source of the estimate and the Pimachiowin Aki.

In general, the authors reported a lack of ecosystem service values in the literature for the multitude of potential EGS benefits. A number of the identified ecosystem services provided by the area were not valued due to a lack of information. Thus, the overall ecosystem service value derived for the site is conservative.

3.3.1.5 Policy/Planning Implications

This study will contribute to the site's nomination for a World Heritage Site by illustrating the area's ecological and social values. The study also aims to promote discussion about alternative and creative ways to finance the operation and management of the Pimachiowin Aki area in the future. For example, Payments for Ecosystem Services (PES) schemes are given as an example of an applied policy for ecosystem service measurement and valuation that is gaining importance as an economically effective way to preserve natural environments and benefit local communities.

3.3.2 Economic Value of Stored Carbon in Protected Areas: A Case Study Of Canadian National Parks

Kulshreshtha, S. and Johnston, M. 2000. *Economic Value Of Stored Carbon In Protected Areas: A Case Study Of Canadian National Parks*. University of Saskatoon. Saskatoon, Saskatchewan.

3.3.2.1 Report Synopsis

This study assesses the economic value of carbon sequestration for Canada's 39 national parks. Combined, Canada's national parks have sequestered approximately 4.43 gigatonnes of carbon in various pools. The authors estimated that if society had to replace this stored carbon, it would cost between $72 -78 billion. However, this value could range between $11 billion to $2.2 trillion, depending upon society's valuation of carbon sequestration.

About 47% of the total stored carbon was in the soils, another 8% in the plant biomass, and the remaining 45% in the peatlands. An examination of the regional distribution of stored carbon indicated that the Boreal ecozones store the largest amount of carbon, led by those located in the Boreal Plains ecozone, where the major type of storage is peatlands. These parks stored 43% of the total Canadian carbon on these areas. The next ecozone cluster that had a large quantity of stored carbon was Northern Canada (Arctic Codillera, Northern and Southern Arctic, Taiga / Tundra), accounting for 37% of the total.

3.3.2.2 EGS Studied

In this study, all Canadian national parks and national park reserves were included. The study included a total of 39 national parks, occupying a total of 26 million hectares. The major objective of this project was to estimate the economic value of carbon sequestration services provided national parks in Canada. The value of carbon is based on the stock of carbon in the selected areas.

The total amount of carbon sequestered (i.e. stored) in a national park was estimated by land cover type (forestland, grassland, and tundra). Furthermore, biomass carbon was split into two pools: carbon stored in aboveground biomass, and carbon stored in the roots (belowground biomass). Much of the information on physical attributes was collected from Parks Canada reports, and supplemented by a survey of all national parks.

The Carbon Budget Model of the Canadian Forest Sector provided a framework to account for the major carbon pools for the forest ecosystems. To facilitate estimation, species were grouped into broadleaf species and coniferous species. The underground biomass (roots) was estimated for all national parks using relationships using reported methodology. Information on the National parks located in the arctic region of Canada was based on an Alaskan study. An average aboveground biomass of 1.9 t/ha was used to estimate the biomass or carbon in grassland ecosystems.

To estimate the carbon content in soils for national parks, the average carbon density of soil carbon pools for each ecoclimatic province was used. Carbon densities were the highest in the sub-arctic ecozones – taiga / tundra cordillera. Peatlands are the most carbon rich resource and provide the largest carbon pool.

In order to value the carbon stored, the authors suggest that the ideal method of valuation would be to develop a damage-avoided approach for global climate change. However, the authors reported that such studies had not yet been conducted at the time of this study. Thus, economic valuation was based on a review of available studies, using the "benefit transfer" approach to valuation. A review of studies was undertaken and those relevant to the study selected. Based on the review of existing studies on the value of carbon, it was concluded that such values are highly variable. The range of values was very wide, ranging anywhere from a low of $Cdn 2 to a high of $Cdn 982 per tonne of carbon in 2000 dollars.[7]

3.3.2.3 Policy/Planning Implications

One of the conclusions of this study is that protected areas in Canada play a significant role in terms of carbon sequestration and its value to Canadians. The authors reported that 39 national parks in Canada have sequestered a total of slightly more than four gigatonnes (4.43 gigatonnes) of carbon. If these carbon pools were lost, Canadian society would need to spend between at least $72 - 78 billion to replace them. The authors suggest that protecting these ecosystems must be one of the major objectives of national parks management. They recommend that human encroachment similarly should be regulated so as to ensure that these values are not lost. In addition, the loss of carbon from these parks would have a major impact on the atmosphere, about 23 times the 2000 level of Canada's annual emissions of approximately 190 Mt.

Kurz, W. A.; Apps, M. J.; Webb, T. M. and McNamee, P. J. 1992. The carbon budget model of the Canadian forest sector: Phase I. Forestry Canada, Northern Forestry Centre, Edmonton, Alberta. Inf. Rep. NOR-X-326.
Coupland, R. T. 1992. Natural grasslands, Introduction and Western hemisphere. Ecosystems of the World 8-A, Amsterdam ; New York : Elsevier.
Kurz, W. A.; Beukma, S. J. and Apps 1996. Estimation of root biomass and dynamics for the carbon budget model of the Canadian forest sector. Canadian Journal of Forest Research 26:10(1973-1979).
Mead, B. R. 1995. Plant biomass in the Tanana river basin, Alaska. Research Paper PNW-RP-477. Pacific Northwest Research Station. Portland, OR: U. S. Department of Agriculture.

3.3.3 Ontario's Wealth, Canada's Future: Appreciating the value of the Greenbelt's eco-services

Wilson, S.J. 2008. *Ontario's Wealth, Canada's Future: Appreciating the value of the Greenbelt's eco-services*. David Suzuki Foundation. Vancouver, BC.

3.3.3.1 Report Synopsis

Southern Ontario's Greenbelt surrounds the Golden Horseshoe - extending about 325 kilometres from the eastern end of the Oak Ridges Moraine to the Niagara River in the west, covering 1.8 million acres. Its area consists of protected green spaces, farmlands, communities, forests, wetlands, and watersheds.

This report quantifies the value of the ecosystem services provided by the Greenbelt's natural capital. The annual value of the region's non-market ecosystem services is estimated at $2.6 billion annually; an average value of $3,487 per hectare. The report also provides land cover and land use information for the Greenbelt and policy recommendations.

3.3.3.2 EGS studied

The Greenbelt study examined the following EGS by land cover type:

- Air quality
- Climate regulation
- Flood control
- Water regulation
- Water filtration
- Erosion control and sediment retention
- Soil formation
- Nutrient cycling
- Waste treatment
- Pollination
- Natural regeneration
- Biological control
- Habitat
- Genetic resources
- Recreation and aesthetics, and
- Cultural

3.3.3.3 Case Study: Methodology

These reports use avoided cost and replacement cost for ecosystem service valuation, as well as contingent valuation or willingness-to-pay studies for cultural values. Some of the values were derived using direct analysis and some values were adapted from other studies (known as “benefit transfer”). All ecosystem service values are reported in 2005 Canadian dollars.

The first step for assessing the value of natural capital is to take stock of the watershed’s natural assets in terms of land and water cover. In the case of this assessment, it is important to accurately identify and classify the land use and ecosystem types across the Lake Simcoe basin in order to assess the ecosystems, functions and their respective services.

Land cover for has been identified and mapped by the Lake Simcoe Region Conservation Authority (LSRCA) through aerial photography interpretation (orthophotography 1999 – 2005) with some field verification. Vegetation communities have been identified using the Ecological Land Classification (MNR1998) while land use was identified to basic categories. The land cover and land-use within the Greenbelt were determined using land cover data from the 2000-2002 Southern Ontario Land Resource Information System (SOLRIS). The Ontario Land Cover (1990-1997) was used for the northern arm of the Niagara Escarpment region because SOLRIS does not include this area yet.

Using the ecosystem classifications by ecosystem function developed from a number of published sources,[8] the potential ecosystem services were ascribed for each land cover type. Based on the ascribed ecosystem services, extensive literature searches were undertaken to find information and data on the measurement of the stock and flows of ecosystem services, as well as relevant monetary valuations for the region. Based on this review the following methods were used for measuring and valuing ecosystem services.

1) Forest Carbon Sequestration, Air Pollution Removal, and Water Regulation

CITYgreen, a GIS application for land-use planning and policy-making, was used for the measurement and valuation of these three ecosystem services.[9] It conducts complex statistical analyses of ecosystem services, and calculates dollar benefits based on land cover and land use data. See Appendix A for detailed methodology. This software was used to calculate:

- the total annual carbon sequestered by the Greenbelt’s tree canopy cover,

- The value and amount of air pollutants removed by the Greenbelt and Lake Simcoe watershed’s tree cover was determined using CITYgreen. CITYgreen calculates the value of air cleansing by trees using average removal rates of carbon monoxide, nitrogen dioxide, nitrogen dioxide, particulate matter and sulfur dioxide by trees.[10] The results show that Lake Simcoe’s watershed tree cover (66,378 ha) removes almost 4 million kilograms of pollutants per year (60

[8] De Groot, R.S. 2002. “A typology for the classification, description and valuation of ecosystem functions, goods and services.” *Ecological Economics*. 41: 393-408.
[9] See Appendix A for detailed methodology. Also refer to CITYgreen website at: http://www.americanforests.org/productsandpubs/citygreen/
[10] CITYgreen software calculates the annual air pollution removal rate of trees using a scientific model developed by the US Forest Service and the pollutants are those that are identified by EPA as the major pollutants. The dollar values are derived by “externality” costs (a method developed by economists) which are indirect costs borne by society. See appendix A for more detailed methodology.

kilograms of pollutants per hectare). The kilograms removed per hectare include: 1.2 kg of carbon monoxide/hectare, 4.2 kg of sulfur dioxide/hectare, 7.5 kg nitrogen dioxide/ hectare, 16.8 kg of particulate matter/hectare, and 30.3 kg of ozone/hectare.

- The amount of water runoff controlled (i.e. water regulation) by the Greenbelt's tree cover (forest and urban parks) in relation to conversion to urban land-use. The value calculated is the replacement cost in terms of the construction costs for water runoff control if the current forest cover was removed and converted for urban land use.

2) Waste treatment by wetlands

Wetlands can absorb nutrients such as nitrogen (N) and phosphorus (P) that run off farmlands in excessive amounts because of fertilizer, manure use, and from livestock. The waste treatment services provided by wetlands in the Greenbelt and Lake Simcoe watershed were estimated based on data from several studies. Studies indicate that wetlands remove 80.3 to 770 kg/ha/year of phosphorus, and 350 to 32,000 kg/ha/year of nitrogen depending on the wetland type, size, plants and soils.[11] Both studies used the low-end estimates for nutrient removal rates multiplied by the total wetland area to measure the estimated capacity of wetland waste treatment for P and N.

Once the capacity for phosphorus and nitrogen removal was estimated for the wetlands in the two study areas, nitrogen and phosphorus runoff needed to be determined. Nitrogen loss from croplands was based on the annual loss of nitrogen that poses a risk for water contamination (10 to 20 kg N/ha) on the majority of Ontario's farmlands (73%), as reported by Agriculture and Agri-Food Canada (AAFC).[12] For example, this average applied to the area of croplands in the Lake Simcoe watershed means an estimated 1.14 to 2.28 million kilograms of nitrogen loss that poses a risk for water contamination per year, These studies report that although Ontario ranked high in terms of total nitrogen runoff (29 per cent of farmland with 30 to 40 kg N/ha and 52 per cent of farmland with greater than 40 kg N/ha), concentrations in water runoff were relatively low. The risk of contamination to water is determined by the ability of the natural ecosystems to regulate, filter and absorb the nutrients in the runoff. This suggests that ecosystem services are treating this waste.

The value of waste treatment is calculated using the costs of waste treatment plants. The costs of removing nitrogen (N) and phosphorus (P) by waste treatment plants have been estimated to range from $22 to $61 per kilogram of phosphorus and $3 to $8.50 per kilogram of nitrogen.[13] The average cost is used as a proxy for the value of wetland

[11] Reported by: Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited Canada and the Nature Conservancy of Canada.

[12] Drury, C.F. et al. 2005. "Nitrogen Use Efficiency." In Lefebvre, A.W. et al. 2005. *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series - Report #2*. Agriculture and Agri-Food Canada. Ottawa, Ontario. http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1182179116194&lang=e (accessed Nov. 2007).

[13] Reported by: Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited Canada and the Nature Conservancy of Canada.

waste treatment services for excess nitrogen, the annual value is an estimated $407 per hectare.

Information on the risk of water contamination by phosphorus was not available for Ontario, so the national average for excess phosphorus (14.3 kilograms per hectare per year) was used. For example, 1.7 million kilograms of excess phosphorus runoff was estimated from croplands in the Lake Simcoe watershed. The capacity for phosphorus removal capacity was calculated using the low-end estimate of wetland treatment capacity for phosphorus from the literature (80 kg/ha/year) multiplied by the wetland area, the wetlands. In the Lake Simcoe watershed, wetlands have the capacity to absorb at least 3.1 million kilograms of phosphorus per year. In this case, the ability of wetlands to ttreat the estimated 1.7 million kilograms of excess phosphorus was assessed. The value of wetland treatment services for excess phosphorus was then calculated for the full excess amount. The value was calculated using the estimated amount of excess phosphorus multiplied by the average cost of phosphorus removal by waste treatment plants (see previous paragraph). In the case of the Lake Simcoe watershed the value is $1,838 per hectare per year.

The two values for nitrogen removal and phosphorus removal were added together to estimate the total value for waste treatment by wetlands. In the Lake Simcoe watershed, the annual total for waste treatment by wetlands was estimated at $83.7 million or $2,148 per hectare. In the Greenbelt study, the value of waste treatment by wetlands was an estimated total of $294 million or $3,017 per hectare per year.

3) Forest water filtration services:
Calculated as the replacement cost of the current condition of the Greenbelt's watersheds. Measurement was based on a U.S. study that concluded that the cost of treatment for surface water supplies varies depending on the per cent forest cover in the water source area.[14] The study concluded that there is a 20 per cent increase in water treatment costs for each 10 per cent loss in forest cover. In other words, where forest cover is low, water treatment costs more.

The results from this study were used to interpret the value of water filtration services by forests and wetlands in the Greenbelt and Lake Simcoe watershed. First, the per cent forest/wetland cover in the study area's watersheds was assessed using land cover data. In the case of the Greenbelt, the proportion of forest/wetland cover in the Greenbelt watersheds, and the per cent cover of forests and wetlands in each major watershed that flows through the Greenbelt: East Georgian Bay, East Lake Huron, North Lake Erie, and Lake Ontario.[15] The average natural cover by forests and wetlands in the Greenbelt was assessed as approximately 30 per cent.

[14] Ernst, C., Gullick, R. and Nixon, K. 2007. "Protecting the Source: Conserving forest to protect water." In *The Economic Benefits of Land Conservation*. The Trust for Public Land. www.tpl.org

[15] The proportion of each watershed's natural land cover is a measure of the integrity of the water flowing through the watershed area.

The valuation for water filtration services is based on the potential increased in water treatment costs if the current forest/wetland cover declined from its current proportion to 10 per cent cover (i.e. as it is unlikely that natural cover would decline to zero). Thus, the value is based on the additional cost for water treatment if the current natural cover declined. The potential additional cost for water treatment was calculated for the Lake Ontario watershed based on the current average cost of water treatment for the City of Toronto ($0.60 per cubic metre). As a result, water treatment costs could increase to $0.94 per cubic metre if the average forest and wetland cover declined to 10 per cent. The difference in cost ($0.34/m3) is the avoided cost or the value of maintaining the current forest and wetland cover. The total estimated municipal water use for the Lake Ontario watershed was used to calculate the total potential additional costs for water treatment if the forest/wetland cover declined to 10 per cent. This total was then ascribed to the total area of forests and wetlands to assess the per hectare value ($474/hectare/year).

The value for water filtration was transferred from the Lake Ontario watershed ($474/ha/year) to all forest and wetland cover in the Greenbelt (276,608 hectares). About half of the Greenbelt watersheds flow into Lake Ontario, 46 per cent into Lake Huron and five per cent into Lake Erie. The total annual value of water filtration services is reported as an estimated $131 million. Of this total value, $86.5 is attributed to forest cover in the Greenbelt and $44.6 million due to wetland cover.

In the case of the Lake Simcoe watershed, the forest/wetland cover was assessed using land cover data at 32 per cent of the total land cover. The potential additional cost for water treatment was calculated for the watershed based on the estimated residential water use in the Lake Simcoe watershed,[16] and the current average cost of water treatment for the City of Toronto ($0.60 per cubic metre) from the Greenbelt report. The value of the current forest/wetland cover for water filtration services was reported as $17.2 million for the Lake Simcoe watershed, an annual value per hectare of $209.86.

4) Water Supply

The value of the Lake Simcoe’s watershed for drinking water is estimated based on the costs for providing residential drinking water (excluding the treatment costs that were used as a proxy for water filtration services). Because the Lake Simcoe report was under tight timeline, the cost of water supply was taken from the City of Toronto. The city of Toronto reports that the cost of water is $1.50 per cubic meter for water and wastewater treatment. $0.50 per cubic meter is for drinking water treatment. The difference ($0.90 per cubic meter) is for all other water and wastewater costs. So the author estimated that 50% would be for water supply. The annual value for natural water supplies was calculated using annual municipal water use multiplied by $0.45 per cubic metre. In other words, the value of the natural infrastructure of water systems that collect, store and distribute our water.

The annual value of water supply in the watershed is an estimated $21.6 million, based on the total daily municipal water use in the watershed (137,736 cubic metres). Given the

[16] The daily residential water use for the Lake Simcoe Watershed was calculated based on annual total water flow data extracted from Environment Canada’s 2007 Municipal Water Use Report: Municipal Water Use, 2004 Statistics. http://www.ec.gc.ca/water/en/manage/use/e_data.htm (accessed June 2008).

109,593 hectares of waterways and wetland in the watershed, it equates to an annual value of $196.88 per hectare of water and wetland cover.

The replacement cost of water supply by waterways from the Greenbelt's watersheds was assessed based on Toronto's cost of water supply (minus water treatment costs) for the GTAH population (Greater Toronto Area and Hamilton).

5) Forest Carbon Storage

The amount of carbon stored in forests was estimated using forest ecosystem carbon content estimates from Carbon Budget Model for Canada's Forests.[17] The National Forest Biomass Inventory (NFBI) is the primary source of data for this model.[18] The carbon content estimates are reported for aboveground and belowground biomass, as well as for dead organic matter in the soils. The estimates are reported by eco-climatic province. The Lake Simcoe watershed and the Greenbelt region's forests are both in the Cool Temperate eco-climate zone. According to the Carbon Budget Model, the Cool Temperate zone's forests store 220 tonnes of carbon per hectare of forest. This average carbon content was applied to the total area of forest in both studies. Because it is an average value across various forest age classes, the average value was applied to all forest area. The total carbon stored was therefore calculated by multiplying the average carbon per hectare by the total forest area. The total carbon stored is reported. In addition, the carbon measurement is converted to carbon dioxide in order to provide the equivalent in carbon emissions due to energy use.

The economic value of the carbon stored by forests is calculated based on the avoided cost because it reflects the actual damages avoided by the carbon stored. Both reports use the average cost of C$52 per tonne of carbon in global damages due to the level of carbon dioxide in the atmosphere in 2005 as reported by the IPCC (Intergovernmental Panel on Climate Change).[19] Two steps were involved in estimating the value. First the average cost of $52 was multiplied by the total carbon stored by forests as calculated in the preceding paragraph. This value provides an estimated value of the stock at one point in time. In order to assess the annual value, the carbon stored by forests was considered as an annuity investment over 20 years. This approach to assessing the annual value of carbon storage is adapted from Anielski and Wilson (2007). Anielski and Wilson (2007) used a relatively short 20-year annuity because of the urgent timeline for carbon management for climate change, and because of the risks to forests associated with climate change if greenhouse gas emissions are not significantly reduced. Each year as the level of carbon dioxide in the atmosphere increases, the value of carbon stored will increase in value.

[17] Kurz, and Apps 1999. "A 70-Year Retrospective of Carbon Fluxes in the Canadian Forest Sector." *Ecological Applications*. 9: 526-547.

[18] Bonnor, G.M. 1982. Inventory of forest biomass in Canada. Canadian Forestry Service. Petawawa National Forestry Institute. Chalk River. Ontario, Canada.

[19] IPCC. 2007: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge University Press, Cambridge, UK, 7-22..

In the case of the both studies, the annual value of the carbon stored by forests is an estimated $919 per hectare in 2005 (C$2005).

6) Carbon storage by wetlands

Carbon stored in the soils and peat of wetlands was determined using Canada's Soil Organic Carbon Database.[20] Data was extracted spatially from this geo-referenced database by land cover type. In the case of the Lake Simcoe watershed, wetlands store 5.2 million tonnes of carbon in their soils and peat. The annual value of the carbon stored is an estimated $21.9 million based on the average damage cost of carbon emissions ($52/tonne of carbon), annualized over 20 years. The soil carbon ranges from 125 to 312 tonnes per hectare depending on the wetland type with values per hectare ranging from $524 to $1,302 per year (i.e. shallow water, bog, marsh, swamp and fen).[21]

7) Annual carbon sequestration by wetlands

The annual carbon sequestered was calculated using a global average sequestration rate for wetlands. These annual rates range from 0.2 to 0.3 tonnes of carbon per hectare. [22] If the average rate (0.25 tonnes per hectare per year) is applied to the area of wetlands in the Lake Simcoe watershed, the annual rate of carbon uptake is 9.743 tonnes, worth $13 per hectare. The author notes that this is a conservative estimate because other studies have found higher rates of carbon uptake.[23]

8) Carbon storage by cropland soils

Carbon stored in the soils and peat of croplands was determined using Canada's Soil Organic Carbon Database.[24] Data was extracted spatially from this geo-referenced database by land cover type. In the case of the Lake Simcoe watershed the average annual value per hectare is $547 per hectare (C$52/tC).[25] The average soil carbon content is 131 tonnes of carbon per hectare, ranging from 125 tonnes to 252 tonnes of carbon per hectare depending on the type of agricultural land cover (i.e. cropland, orchards, idle land and hedgerows).

In addition, annual carbon sequestration by land in permanent cover was estimated because it sequesters more carbon than tilled land.[26] Although the rate of sequestration depends on the type of cover, the change from conventional crop tillage to permanent

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[20] Tarnocai, C., and B. Lacelle. 1996. *Soil Organic Carbon Database of Canada*. Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Canada.

[21] Author's calculation using carbon estimates and the average social cost of carbon from IPCC FAR report (US$43/tC or C$52/tC in 2005). Each year as the level of carbon dioxide in the atmosphere increases, the value of carbon stored will increase in value.

[22] Carbon balance of peatlands. http://www.aswm.org/science/carbon/quebec/sym43.html

[23] Fluxnet Canada. Peatland Carbon Study. Mer Bleu Eastern Peatland. http://www.trentu.ca/academic/bluelab/research_merbleue.html

[24] Tarnocai, C., and B. Lacelle. 1996. *Soil Organic Carbon Database of Canada*. Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Canada.

[25] The total value of carbon stored was converted to an annual benefit, as an annuity over 20 years at 5%. The average global cost of carbon emissions is reported by the Intergovernmental Panel on Climate Change, $52 per tonne of carbon in 2005.

[26] Sala, O.E., and Paruelo, J.M. 1997, "Ecosystems Services in Grasslands". In: *Nature's Services: Societal Dependence on Natural Ecosystems*, G.C. Daily (Ed.), Island Press, Washington, D.C..

cover has been estimated to increase sequestered carbon by 1.8 tonnes of carbon dioxide (0.5 tC) per hectare per year compared with conventional crop cover.[27] Based on this information, both studies attributed 0.5tC/ha/year to these cover types with an estimated value of $28.46 per hectare ($52/tC).

9) Habitat Values

The annual value for wetlands habitat services was estimated at $5,830 per hectare for both studies. This value is based on the average annualized wetland habitat restoration costs for a group of relevant Great Lakes Sustainability Fund projects.[28] Projects include the Rouge Watershed Wetland Creation Project, Humber Bay Shores Butterfly Meadow, and the Granger Greenway Habitat Enhancement project. The annualized value of restoring habitat represents the value of wetland habitat in terms of the avoided cost of damages to habitat which is particularly important in southern Ontario where approximately 70 per cent of wetlands have been drained for other land use such as agriculture and urban development.

10) Pollination Services

In both studies, the value of pollination was calculated as 30 per cent of the current value of agricultural production in the study area. The 30 per cent is a global estimate for the average food crops that are dependent on pollination. Then this value is attributed to the land cover types that provide habitat, forage and food for wild and managed pollinators. Their literature review concludes that the proximity of natural habitat to cropland is significant for optimum yields and increased farm production. For example, they report a Canadian study that found canola yield is correlated to the proximity of uncultivated areas.[29]

Based on the importance of natural cover and habitat for both honeybee and wild pollination services, both studies examined the proximity of cropland to natural cover in the study area to assess the availability of natural cover for pollinators. In the Lake Simcoe watershed 91 per cent of the agricultural lands have 20 to 40 per cent natural cover within a two kilometre radius and in the Greenbelt 96 per cent of agricultural lands have 20 to 60 per cent natural cover within a two kilometre radius. As a result, the value of pollination was attributed to natural land cover types in the study areas by dividing the total value through by the total natural cover area. The natural cover types included idle agricultural lands, grazing lands (perennial croplands), hedgerows/cultural woodland, forest lands, and grasslands with an average annual value per hectare of $951 in the Lake Simcoe watershed and $1,109 in the Greenbelt study.

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[27] Smith W.N. et al. 2001. "Estimated changes in soil carbon associated with agricultural practices in Canada." *Canadian Journal of Soil Science*. 81:221-227. (used by Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited and Nature Conservancy of Canada.)

[28] IJC Study Board. 2006. *Valuating Wetland Benefits compared with Economic Benefits and Losses*. International Lake Ontario – St. Lawrence River Study. http://www.losl.org/PDF/Wetland-Value-Paper-April-27-2006-e.pdf (accessed Nov. 2007)

[29] Greenleaf, S.S., and Kremen, C. 2006. "Wild bee species increase tomato production and respond differently to surrounding land use in Northern California." *Biological Conservation*. 133:81-87; Greenleaf, S.S., and Kremen, C. 2006. "Wild bees enhance honey bees' pollination of hybrid sunflower." *Proceedings of the National Academy of Sciences*. 103:13890-13895.

11) Recreation and Tourism Values
In the Lake Simcoe study, the amount spent annually on tourism and recreation in the watershed as reported by a local study was used to reflect the value of recreation supplied by the natural cover and water cover. The annual value of recreation services was estimated at $1,231 per hectare for forest, wetland, grassland and water cover.

In the Greenbelt report, the value of recreation is based on a 1996 federal government survey that estimated the economic impact of nature-based recreation and the willingness to pay for nature-based activities.[30] Ontario's annual nature-based recreation value from this survey is $6.4 billion in 2005 dollars. In order to interpret this value for the Greenbelt, 50 per cent of the annual provincial value ($3.2 billion) was assumed to take place on the province's protected lands. According to the Ontario government, about 9.5 million hectares of land is protected in Ontario, thus the annual recreational value per hectare of protected land is an estimated $335.[31] Based on this value, the total annual recreational value for forests, wetlands and water cover types in the Greenbelt is $335 per hectare.

3.3.3.4 Strengths and Weaknesses

In general, identifying the goods and services of an ecosystem and measuring their value is difficult because of a lack of ecological and economic information. Measuring the non-market values of ecosystem services are difficult to quantify because most do not have an established price.

The limitations reported for the Greenbelt study include: 1) the availability of ecological information, 2) data on the current state of ecosystems and land, and 3) studies documenting the impacts of human land use on ecosystem services. In addition, the author reports that the estimated values are likely a conservative estimate because not all ecosystem goods and services can be valued.

3.3.3.5 Policy/planning Implications

This report was aimed at illustrating the value and benefits of the southern Ontario Greenbelt for its communities as well as the surrounding communities. It showed support to the province for establishing the Greenbelt and asks for effective implementation of the policies of the Greenbelt Plan.

The report emphasizes the importance and value of natural capital as an essential part of land-use planning and policy decisions by the provincial and municipal governments and the Ontario Municipal Board (OMB). The ecosystem values presented in this report can be one input for determining the potential changes in ecosystem services due to land use

[30] Duwors, E. et al. 1999. *The Importance of Nature to Canadians: The Economic Significance of Nature-Related Activities*. Environmental Economics Branch. Environment Canada. Ottawa, Canada.
[31] Area of Ontario's protected lands is from: Ontario's State of the Forests Report 2006. http://www.mnr.gov.on.ca/MNR_E005278.pdf

and other decisions. The findings can also be useful in helping to establish priorities to invest in our natural capital and ensure it continues to yield benefits.

The report also relates natural capital and ecosystem service values to climate change planning and policy. The projected impacts of climate warming will place additional pressure on ecosystems, which will have greater repercussions in areas where ecosystems are already stressed and in decline. Human pressures on natural ecosystems need to be reduced in order for our ecological systems to cope and adapt in the face of climate change.

In addition the following recommendations were put forward based on the findings of the report:

- Growing the Greenbelt: Given the ecological value of the Greenbelt and the connected ecosystems beyond, and the vulnerability of natural areas and agricultural lands in southern Ontario, it would be prudent to include additional land in the Greenbelt.

- Provincial Leadership: Given the essential services provided by the Greenbelt's ecosystems, it is important that the province maintain its strong leadership role in the implementation of the Greenbelt Plan, working collaboratively with municipalities and conservation authorities who have a key role in conserving and enhancing natural capital.

- Natural and Hydrological Features Classification: A critical piece of ongoing work by the provincial and municipal governments is the identification of key natural heritage and hydrological features. This will facilitate efforts to conserve them and the benefits they provide.

- Municipal Leadership: Municipalities should work with conservation authorities and local communities to enhance the resiliency of and benefits provided by ecosystems. This includes wetland creation, tree planting, and park and trail expansion and creation.

- Stewardship Funding: The provincial government should enhance its financial support for stewardship and other incentive programs that recognize and reward farmers' efforts to conserve the natural soil, water, air and biodiversity resources of the Greenbelt and the connected ecosystems.

- Education and Awareness: It is important that provincial and municipal governments as well as conservation authorities and non-governmental organizations continue to fund and deliver public education programs that build awareness of the role of natural capital in providing clean air, clean water, healthy food and wildlife protection.

3.4 Conceptual Studies

3.4.1 Monitoring the Value of Natural Capital: Water

Gardner Pinfold Consulting Economists Ltd. 2002. *Monitoring the Value of Natural Capital: Water*. (Prepared for Environment Canada and Statistics Canada).

"Monitoring the Value of Natural Capital: Water" was a three-year pilot project developed jointly by Environment Canada and Statistics Canada, was established to develop a methodology that could be used to value water for a broad range of Canada's environmental assets; to set-up a framework for a monetary national water resource accounts that could be integrated in a satellite account for natural resources; and, to derive a national estimate of the value of Canada's water resources

A key component of the pilot study is the recognition that components of natural capital, including water, may have many uses and that a true measure of its worth requires estimates of both non-market and market values. Water valuations can be used to extend the national income accounts and to track how these values may change with use and changes in quality. Second, values of water, separate from their use in the national accounts, provide decision makers with a metric to judge competing uses for water.

The report develops a framework for valuing water by first categorizing water uses including industrial water use, commercial uses, power generation and non-consumptive uses among others relevant for both Total Economic Value or System of National Accounts. Secondly it provides a comprehensive list of water use/functions and water uses are classified according to four major types of total economic values - direct use, indirect use, option values and passive use. A review of the water valuation techniques is provided that examines the strengths and weaknesses of different approaches such as cost of intake, market price of water, cost of alternative supply, hedonic price, travel cost, and cost of illness among others.

Policy/Planning Implications
The authors recommend that a systematic and long-term commitment to data collection in the area of water usage in Canada (municipal, industrial, commercial, institutional, recreational, and other indirect uses). They recommend that two pilot studies be conducted on watersheds, sub-basins or aquifers within Canada applying the methodologies outlined in the valuation framework.

4 Important Data Sources for EGS Studies in Canada

EVRI – Environmental Valuation Reference Inventory
www.evri.ca
The EVRI is a searchable storehouse of empirical studies on the economic value of environmental benefits and human health effects. It has been developed as a tool to help

policy analysts use the benefits transfer approach. Using the EVRI to do a benefits transfer is an alternative to doing new valuation research

Geoconnections / Conservation Areas Reporting and Tracking System (CARTS) database
www.geoconnections.org
Launched in 1999 with $60 million in federal funding, this national partnership program was mandated to develop the policies, standards, technologies, and partnerships needed to build the Canadian Geospatial Data Infrastructure (CGDI). The CGDI gives decision-makers access to online location-based information in the form of detail-rich digital maps or satellite images.

SOLRIS – Southern Ontario Land Resource Information System
SOLRIS is a regional, ecologically based, land cover / land use inventory. It provides a comprehensive, landscape-level inventory of natural, rural and urban areas in Southern Ontario. The land cover / land use classification follows the standardized Ecological Land Classification for southern Ontario to describe, inventory and interpret land cover for ecoregions in southern Ontario. The inventory represents the landscape current to 2000 to 2002. Version 1.2 includes all of Southern Ontario with data classes including: exposed bedrock, shoreline, forest, agriculture (annual, mixed and perennial crop), vegetation, transportation, built-up areas and water. Detailed descriptions of each classification are included with the documentation available with the downloaded files. Ask staff for assistance in accessing the documentation files. This data is made available through the Ontario Geographic Data Exchange (OGDE) program as a part of the Land Information Ontario (LIO) data warehouse.

Forest Carbon
Kurz, and Apps 1999. "A 70-Year Retrospective of Carbon Fluxes in the Canadian Forest Sector." *Ecological Applications*. 9: 526-547.

Forest Biomass
Bonnor, G.M. 1982. Inventory of forest biomass in Canada. Canadian Forestry Service. Petawawa National Forestry Institute. Chalk River. Ontario, Canada.

Soil Carbon
Tarnocai, C. and B. Lacelle. 1996. *Soil Organic Carbon Database of Canada*. Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Canada.

5 Table of Annual Values from Studies Reviewed

Study Area	Author	Method	Forest	Wetland	Grassland	Pasture	Water Regulatio n	Carbon storage	Total	Total /ha	Notes
Boreal region	Anielski/ Wilson	mixed	$788/ha					$582 B	$703 B	$1,024	
Mackenzie	Anielski/ Wilson	mixed	$78.8 B	$$181.7 B	$12 M		$8,209/ha	$339 B $820/ha	$570.6 B	$3,426	
Canada	Env Canada	surveys economic impact							$11.7 B		
L Simcoe watershed	Wilson	mixed	$4,798/ha	$11,172/ha	$2,727/ha	$1,479/ha	$1,428/ha	$145/ha	$975 M	$2,948	
Pimachiowin Aki	Voora/Barg	benefit transfer					$32 M	$12-$20 M	$121 to $131 M		
National Parks	Kulshreshtha /Johnston	mixed						$72B to $2.2 T			
Ont Greenbelt	Wilson	mixed	$5,414/ha	$14,153/ha	$1618/ha	$477/ha		$366 M	$2.6 B	$3,487	
Lower Fraser Valley	Olewiler	Benefit transfer/ local analysis	$2000/ha	$860 to $3380/ha	$230/ha	$230/ha	$408 to $2,110/ha	$15 to $608/ha			
Grand R watershed	Olewiler									$195/ha	net va restor
Upper Assiniboine R	Olewiler									$65/ha	net va restor
Mill R Watershed	Olewiler									$126/ha	net va restor

6 Models

6.1 Marxan

Marxan is the most widely used conservation planning tool in the world and is used by more than 1300 users in over 80 countries worldwide. Marxan is software that delivers decision support for conservation planning. It was designed to help inform the selection of new conservation areas for minimal cost, and facilitate the exploration of trade-offs between conservation and socio-economic objectives. Marxan can help set priorities for conservation action by highlighting those places that are likely to be important inclusions in an efficient reserve network. Marxan can also be employed as a tool for evaluating how well existing reserve networks achieve the goals of representativeness and comprehensiveness.

For example, Kai Chan and associates at UBC characterized and mapped terrestrial biodiversity and six ecosystem services to develop networks of conservation areas for the central coast of California for each ecosystem service, by using a spatially explicit conservation planning framework (MARXAN v 1.8.2).[32] Marxan is freely available online at http://www.uq.edu.au/marxan/index.html?p=1.1.1 .

6.2 InVEST

The Natural Capital Project, a joint venture among The Woods Institute for the Environment at Stanford University, The Nature Conservancy, and World Wildlife Fund, has developed,InVEST, a new tool that can model and map the delivery, distribution, and economic value of ecosystem services. The tool will help users visualize the impacts of potential decisions, identifying tradeoffs and compatibilities between environmental, economic, and social benefits.

InVEST 1.0 includes models for carbon sequestration, pollination of crops, managed timber production, water pollution regulation and sediment retention for reservoir maintenance. It also includes a biodiversity model so that comparisons and tradeoffs between biodiversity and ecosystem services can be analyzed. The next release of InVEST will include a suite of new ecosystem services: flood mitigation, agriculture production, irrigation, open access harvest and hydropower production. The tool is modular in the sense that you do not have to model all the ecosystem services listed, but rather can select only those of interest. The InVEST tool can be downloaded at http://www.naturalcapitalproject.org/InVEST.html

[32] Chan, K.M.A., M.R. Shaw, D.R. Cameron, E.C. Underwood, and G.C. Daily. 2006. "Conservation planning for ecosystem services." *Public Library of Science Biology*. 4(11): 2138-2152. http://www.plosbiology.org/article/info:doi/10.1371/journal.pbio.0040379

6.3 CITYgreen

CITYgreen is GIS (Geographic Information System) software that is an extension to ArcGIS. It analyzes the ecological and economic benefits of tree canopy and other green space. The analysis is based on landcover data that is provided by the user. The source of the landcover dataset can be derived from a variety of sources, such as aerial photography or satellite imagery. All versions of CITYgreen analyze the following:

Stormwater Runoff
The stormwater model was developed by NRCS (Natural Resource Conservation Service, a division of USDA). Using this model, CITYgreen calculates the volume of runoff coming from the landcover based on a 2 year 24 hour rain event. More impervious surfaces generate higher levels of runoff, while more natural areas decrease the amount of runoff. This becomes a powerful modeling tool for planning and zoning. CITYgreen reports the runoff volume and dollar value associated with removing any excess stormwater resulting from changes in landcover, such as constructing a retention or detention pond.

Air Pollution Removal
The air pollution model was developed by the US Forest Service and calculates the pollutant removal capacity of tree canopy. The results of the model show how much of five air pollutants the tree canopy is removing from the atmosphere. The greater the tree canopy, the more air pollution is removed. This is a useful tool when a community is trying to meet EPA air quality requirements. CITYgreen reports the annual quantity of pollutants removed and the dollar value associated with these services.

Carbon Storage and Sequestration
This model was developed by the US Forest Service and calculates the amount of carbon stored in the trees represented on the landcover map and calculates the annual carbon removal by the trees.

Landcover Breakdown
From the user-provided landcover map, CITYgreen reports the area for each landcover feature (impervious surface, tree canopy coverage, open space etc.). These areas are reported both as the actual number of acres and as a percentage of the total area. This is very useful when communities are establishing tree canopy goals or managing their land use.

Alternate Scenario Modeling
One of the most powerful features of CITYgreen is the ability to analyze alternate scenarios. Starting with a current landcover map, the effects of future landcover change can be calculated before those changes are made. It is also useful to see how things have changed over time, by comparing landcover maps from earlier periods, such as 10 or 20 years ago. This becomes an important decision-making tool as communities are faced with growth and development choices.

CITYgreen can be purchased at
http://www.americanforests.org/productsandpubs/citygreen/

6.4 EcoValue

Based at the University of Vermont, the EcoValue project provides a decision support system for assessing and reporting the economic value of ecosystem goods and services in a geographic context. The project combines Geographic Information Systems (GIS) and relational database technology to provide interactive maps, graphs and statistics that are generated by linking together the best available peer-reviewed valuation literature and GIS land cover layers in a flexible web-based platform.

The EcoValue model has been used for assessments of EGS in Maryland, the northeastern states' forests in the U.S. and New Zealand. Each module has an interactive map viewer. For example, the Maryland module is intended to provide a watershed-based decision support tool for Maryland citizens and decision makers. The interactive decision-support module, MDNR Map Viewer, is designed to provide the best available information using maps, graphs and figures that explain the economic value of ecosystem goods and services in the State of Maryland. Results of all queries using the Map Viewer are downloadable in both spreadsheet and graphic interchange formats so that the information can be readily used. The EVP modules can be viewed at http://ecovalue.uvm.edu/evp/default.asp .

6.5 The Natural Assets Information System (NAIS)

The EcoValuation Group has developed the Natural Assets Information System™ (NAIS), a framework for quantifying, modeling, and mapping the non-market value of ecosystem services. It combines a database, populated with results from their research, with digital mapping tools and a set of interfaces that can be customized for each user's needs. They have developed a database summarizing hundreds of peer-reviewed studies using ecological and economic methods to estimate economic values for services associated with environmental resource types, such as wetlands, forests, grasslands, or urban green space. In this database, value estimates are coded by ecosystem service and environmental resource type, as well as by geographic region, valuation methodology used, and year. Where primary valuation estimates are not available for a project site, values are "transferred" in which the database is queried for relevant valuation estimates from similar contexts. Using Geographic Information Systems (GIS) technology, NAIS creates digital maps that classify land areas based on their differences in ecosystem service provision. These classes are then linked to valuation estimates from the database, allowing for the creation of maps showing the distribution of valuation estimates. The NAIS is an ecosystem valuation tool developed and used by the EcoValuation Group, a consortium of three consultant firms, (see www.ecovaluation.com or www.sig-gis.com).

7 Discussion

A common conclusion from several of the reports reviewed is that one of the main reasons for ecosystem degradation is the exclusion of natural capital in our current measures of progress and in decision-making. The GDP measures what we buy and sell, or the market value of goods and services. Values not reflected in market prices are considered externalities. For example, the value of a forest or grassland in controlling stream-bank erosion and sediment load in a river is not reflected in the market price of land. Nor is the value of a swamp in recharging an aquifer reflected in the price of water. Therefore, cutting forests and converting land for agriculture or urban development count monetary income without accounting for losses in natural capital.

In most cases, we do not recognize the non-market value of natural capital until services become so degraded or scarce that we have to pay to replace what had been previously provided for free. Similarly, the costs of our impact on the environment, such as losses/damages in ecological services due to pollution, are not taken into account. As a result, the way in which we measure and count our environmental, social and economic well-being is currently misleading.

The recognition and valuation of ecosystem services are emerging trends at the global, national and regional level. For example, the United Nations Millennium Ecosystem Assessment (MA) reported on the condition of the world's ecosystems and their ability to provide services today and in the future.[33] The MA found that over the past 50 years humans have changed the Earth's ecosystems more rapidly and extensively than in any other period in human history. Several of the studies that this paper reviews have either adopted the MA framework or used components of the study's classification system. As communities and governments are beginning to recognize the essential services that natural areas provide, more research and policy options are being explored.

This review on the status of EGS research in Canada demonstrates that interest in defining and valuing ecological goods and services is growing. Regionally, studies have been undertaken to assess the value of EGS in the boreal region including the Mackenzie watershed, the Great Lakes Basin, the southern Ontario Greenbelt, as well as the economic value of nature-related activities across Canada. Watershed and wetland studies have been conducted in watersheds such as Broughton's Creek in southwestern Manitoba, the Credit Valley in southern Ontario, Lake Winnipeg and Lake Simcoe. The value of conserving natural cover was in agricultural regions was assessed in several case studies for the Lower Fraser Valley in British Columbia, Grand River watershed in southern Ontario, the Upper Assiniboine river basin in Saskatchewan, the Mill River watershed on PEI.

7.1 Trends in EGS Valuation

In the studies reviewed, the highest values were assessed for carbon storage services and water-related services such as water regulation by wetlands and water filtration services provided by forests. Climate regulation through carbon storage and sequestration has become one of the popular ecosystem services studied. This is because of its importance in terms of the rapid increase of carbon dioxide in the atmosphere and the predicted damages due to climate change. Carbon is becoming easier to value because several

33 http://www.millenniumassessment.org/en/Condition.aspx

sophisticated studies at the international, national and regional levels have evaluated the damage costs of the increasing concentration of carbon dioxide in the atmosphere. In addition, several pseudo-markets have been set up for carbon trading including the European Union carbon allowance trading market and voluntary carbon offset markets. These markets are establishing trading prices for reductions in greenhouse gas emissions in terms of carbon dioxide equivalents (e.g. carbon dioxide emissions, and other GHGs). Trading prices can be used as a minimum value for the value of carbon storage or sequestration, however they do not reflect the replacement value of storing carbon that has been released to the atmosphere nor the damages caused by the additional carbon contribution to the atmosphere. In the studies reviewed, values for carbon storage range from $15 to $820 per hectare.

Water regulation and supply services provided by wetlands and forests feature predominantly in many of the studies that evaluated non-market EGS. In the case of the assessment of the southern Ontario Greenbelt's eco-services, water filtration by forests and wetlands was measured as the avoided cost of increased human-built water treatment as a result of additional forest/wetland cover losses in the watersheds. In the Pimachiowin Aki (P.A.) study, water related values were based on contingent valuation transferred from an earlier study where the average willingness to pay for improved water conservation and protection by Manitobans was approximately $420 per household per year. Water supply services were estimated based on the water supply volumetric value from a study of the Assiniboine Aquifer water supply ($40,000 to $80,000 per cubic metre). Applied to the main rivers volume of flow in the P.A. study the potential economic value was estimated to range from $0.27 to $5.55 billion. Water regulation values reported in the studies reviewed ranged from $408/ha/year to $8, 209/ha/year.

The value of recreation and nature-based tourism are both becoming relatively well developed in terms of the availability of EGS research and values. Many jurisdictions or organizations that have begun EGS research tend to begin with compiling values on tourism and recreation because statistics on use, recreational activities/habits, spending and costs are compiled by tourism departments as well as nature based recreational areas such as parks and protected areas.

In academic peer-reviewed literature, most studies focus on willingness to pay/accept valuation approaches for EGS. These studies tend to focus on human health related services such as air quality and water quality, as well as less tangible values such as wildlife preservation, landscape views, and protected wilderness.

The less tangible values in general are those EGS that are not highly recognized and often they are ecological functions that are difficult to measure. The value of biodiversity in terms of the EGS provided are more difficult to value effectively including services such as pollination, pest control, and soil formation. There is generally a lack of information on these services both in terms of their biological role, measurement and economic information on their value to society.

The economic benefits in terms of market values such as resource extraction and tourism revenues and impacts have more commonly been compiled than non-market values because they are more readily available and quantifiable. Studies that have considered non-market EGS tend to focus on the values of forests and wetlands because there is often more information, data and peer-reviewed papers on the measurement and value of EGS in these ecosystem types. There tend to be gaps when it comes to EGS values for grassland, alpine and marine systems.

Studies such as Olewiler (2005) and Ducks Unlimited wetland studies have identified and valued some of the non-market EGS associated with agricultural lands. However, there is still a significant lack of information on the EGS provided by agricultural lands, how to measure them, how to value their flow and the impact of agricultural practices and land use on the availability and flow of ecosystem services. As a result, progress on developing incentives for best management practices associated with enhanced EGS is slow compared to programs in Europe and the United States.

Gaps in Information and Valuation

There are three major gaps for EGS measurement and valuation research in Canada. First, there is a lack of information and data on ecosystems and EGS. Most studies have to use land cover and land use data where it can be found, and then ascribe EGS to ecosystem types and land use based on literature reviews that describe the EGS provided by ecosystem types and land use types.

There is no standard approach to establishing and/or mapping land cover and ecosystem services as a planning and public information tool at any of the jurisdictional levels in Canada. This is a result of a lack of consistent approach in mapping across jurisdictions, as well as a lack of land cover and land use mapping altogether in some jurisdictions. In addition, there is a lack of staff personnel assigned or designated to work on developing land cover data and the identification of EGS.

Another large gap in EGS research is how to measure the current condition of ecosystems and their ability to provide EGS. This is a key missing piece to this area of study for without the ability to measure the condition of ecosystems the value assigned does not necessarily reflect the current flow of EGS. For instance, a partly degraded wetland provides fewer services than a healthy one. Part of the problem is that EGS are not identified and monitored as natural capital accounts by jurisdictions in Canada. Thus, they cannot be measured and monitored.

One example where the current condition of the watershed is accounted for is the Greenbelt study. In this study the value of water filtration by forest and wetland cover was measured based on the current average watershed forest cover. As such the value reflects the current condition of the watershed and its ability to provide the ecosystem services (e.g. as the percent forest cover declines water treatment costs increase).

Methodological Challenges

Methodological problems do exist because there is no existing standard approach to measuring and evaluating EGS. There is an existing overall approach of Total Economic Value, as long as methods are used that generate the same types of values (either marginal or average) they are compatible. Partly this is a result of the issue of a lack of data and information on EGS as mentioned above. Because there is very little information on EGS, most studies have to comb the literature for EGS measurement and valuation studies that can be applied to a specific study area or region. And, because there is not a lot of primary research being done, authors have to rely on benefits transfer to get values. This results in different methodologies and valuation techniques being developed and/or transferred for each study undertaken.

Limitations of Ecosystem Service Valuation Research

Identifying the goods and services of an ecosystem and measuring their values are difficult because of a lack of ecological and economic information. Measuring the value of goods or services is fairly straightforward when they have a market-determined value. However, non-market values of ecosystem services are much more difficult to quantify because they do not have an established price.

Although the methodologies are not yet perfected, it is better to work with approximations than to simply assign a value of zero when designing policy or making land-use planning decisions. Based on thorough literature review and the application of economic valuation methods, estimates can be meaningful. Limitations in conducting ecosystem service valuation research include: 1) the availability of ecological information, 2) lack of data on the current state of ecosystems and land, and 3) a lack of studies documenting the impacts of human land use on ecosystem services.

In addition, estimated values for non-market ecosystem services are generally conservative estimates due to our incomplete understanding of *all* the benefits provided by nature, the intrinsic value of nature itself and the likely increase in ecosystem service value over time, as services such as water supply become increasingly scarce due to global warming, for example. However, valuations of ecosystem services provide an opportunity to rigorously assess the current benefits of an area's natural capital and the potential costs of human impact.

Impacts of Climate Change

Natural capital and ecosystem services are in decline worldwide. The current and projected impacts of climate change will place additional pressure on our ecosystems in terms of their ability to function and supply regular services such as water, flood control and pollination. As these impacts continue to grow, communities with low coping ability (i.e. low ecological resilience) will find themselves struggling with diminished green "infrastructure", making them most vulnerable to adverse and costly outcomes. For example, as the climate warms more frequent storm events are predicted for some regions. Communities without intact watersheds that provide flood control through water filtration and wetland water storage are likely to experience greater impacts for such events and more costly damage.

Given the fundamental importance of biodiversity to human societies, many economists now believe that the loss/degradation of natural areas has a cost in terms of the provision of such critical ecosystem services. For example, declines in the populations of bees, butterflies and other pollinators as a result of habitat destruction, pesticide use and invasive pests have been estimated to cost farmers millions of dollars each year in reduced crop yields.

As a result, communities and governments are beginning to recognize the essential services that natural areas provide. The recognition and valuation of ecosystem services are emerging trends at the global, national and regional level.

8 Suggestions for Future Research

1) Municipal and provincial as well as conservation/watershed authorities need to begin to identify, measure, and monitor EGS as part of their jurisdictional reporting. All levels of government should develop natural capital accounts as part of an accounting system that includes reporting on:

- the annual state and extent of land/water cover including changes over time.
- the annual measurement of key and critical EGS including changes over time (e.g. air quality, water quality, carbon storage, waste treatment and flood control)
- the annual value of key and critical EGS in terms of market and non-market values that reflect changes over time; and,
- an account of the losses in value due to human impact on ecosystems and their EGS including damages incurred that result in a decline in the flow of EGS as well as the cost of restoration and reclamation.

2) The development of a standard approach for the measurement and valuation of EGS for Canada would greatly improve this area of research. A national working group of key academic researchers and practitioners could develop a model that would include models by region/dominant land cover/land use with allowance for regional adaptation.

3) EGS and agricultural land use is a research area that needs to establish a standardized approach to measure the non-market ecosystem services provided by agricultural lands. There is also a need to establish values based on the level of ecosystem services provided by selected level of conditions of ecosystems, as well as those best management practices that should be rewarded and programs to implement incentive based payments.

4) Promotion of applied EGS research to support policy decision-making. There is a need for studies that look at changes in marginal values (rather than total values), and the impacts that various policies have on ecological goods and services. This would help decision-makers choose between competing policies or resource uses, in light of whether the changes in net benefits from a decision are greater or equal to the costs involved.

9 Annex 1 – Values & Outcomes Reported

9.1 Regional Studies

Anielski, M.A. and Wilson, S.J. 2005. *Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems*. The Pembina Institute and Canadian Boreal Initiative. Ottawa, Canada (2009 update).

Values/Outcomes Reported

Study Results

- Values
- The total market values of natural capital estimated at $62 billion. Net market value of natural capital extraction estimated at $50.9 billion (total minus costs of pollution and subsidies; $11.1 billion). The total non-market value an estimated $703.2 billion. The ratio of non-market to market values is 13.
- Total market values of boreal natural capital extractions est. $62 billion/year
- Canada's boreal forest contributed an estimated $18.8 billion to Canada's GDP from harvested timber.
- Mining, oil and gas sector contributed $23.6 billion to Canada's GDP.
- Hydroelectric generation from dams and reservoirs in the Boreal Shield ecozone contributed $19.5 billion to Canada's GDP.
- An estimated $11.1 billion in air pollution and government subsidy costs associated with forestry and mining sectors.

- Forests
- Total non-market value estimated at $190.6 billion ($788/ha/year)
- An estimated 47.5 billion tonnes of carbon stored in the boreal forests worth $180 billion for annual amortized value of stored carbon.
- $18 million for watershed services
- $575 million in subsistence values for Aboriginal peoples
- $79 million in non-timber forest products
- $5.4 billion in pest control services by birds ($21.48/ha/year)
- $12 million in passive conservation value (WTP for conservation per household for 50% of boreal households; $16.81/hhld)
- $4.5 billion for nature-related activities (6.1 million Canadians participated in nature related activities in boreal region; $18.53/ha/year)

- Wetlands & Peatlands
- $401.9 billion for annual amortized value of carbon stored in peatlands based on the avoided social cost of carbon reported by IPCC.
- $3.4 billion for flood control, water filtering and biodiversity value by non-peatland wetlands

- $77 billion for flood control and water filtering by peatlands

- Natural Capital Stocks
- 14.7 billion cubic metres in standing timber
- 242 million hectares in total forest land area
- 47.5 billion tonnes of carbon stored in forests
- 2.8 million hectares of wetlands in boreal region
- 83.2 million hectares of peatlands in boreal region
- 106 billion tonnes of carbon stored in peatlands
- 59.2 million hectares of lakes and 4.1 million hectares of reservoirs
- 23,819 hectares of habitat for whooping cranes (5.5% of habitat impacted by development)
- 514,078 hectares of southern mountains woodland caribou habitat (57.7% of habitat impacted by development)
- 22.6 million hectares of boreal woodland caribou habitat (12.7% impacted by fragmentation from development)
- 9.6 million hectares of woodland bison habitat (12.7% habitat fragmentation)
- 20.1 million hectares of wolverine (western region) habitat (7.7% habitat fragmentation)
- 5.6 million hectares of wolverine (eastern region) habitat (5.2% habitat fragmentation)
- 53.75 million hectares of boreal region is designated as protected (9.2% of region)
- mining sector, and oil and gas development footprint is 46.25 million hectares (7.9% of region)

- Flows
- 95.2 million cubic metres of timber harvested annually in 2002
- 2.46 million hectare forest burned annually (1980-1997)
- 92.9 million hectares of boreal forest land fragmented due to linear disturbance from industrial development/footprint
- 368 million cubic metres of water per year (municipal water use; data incomplete)
- 4,911 tonnes of total carcinogens and toxic substances by industry
- 1.4 million tones of total emissions to air of SO_2, NO_2, $PM_{2.5}$ and 78,668 tonnes of VOC
- 14 million tones of carbon emissions due to fossil fuel use by forest products sector

Anielski, M.A. and Wilson, S.J. 2007. *The Real Wealth of the Mackenzie Region: Assessing the Natural Capital Values of a Northern Boreal Ecosystem*. Canadian Boreal Initiative. Ottawa, Canada (2009 update).

Values/Outcomes Reported

Values

- The market value of the Mackenzie watershed estimated at $41.9 billion per year, an average of $246 per hectare.
- Forestry sector est. market value of $2.7 billion ($200/ha/year)
- Mining, oil and gas sectors est. market value of $30.4 billion ($1,065/ha/year)
- Agriculture market value of $878 million ($255/ha/year).

- The total non-market value assessed as the potential value of 17 ecosystem services produced by the region estimated at $570.6 billion per year, an average of $3,426 per hectare.
- Key ecosystem services in terms of their estimated value are the value of climate regulation and water stabilization, regulation and supply.
    - Carbon stored by forests, wetlands and tundra worth an estimated $339 billion - carbon storage by forests $820/ha/year (amortized over 20 years)
    - Water regulation $$8209.43/ha/year
    - Water supply $3191/ha/year

- ESP values reported by ecosystem type:
    - Water bodies $188.6 billion
    - Wetlands and peatlands $181.7 billion
    - Tundra permafrost $113 billion
    - Forests $78.8 billion
    - Burned areas $3.7 billion
    - Cropland $297 million
    - Grassland $12 million
    - Mosaic land $604 million
    - Transition treed shrubland $6.6 billion
    - Urban $0.7 million

- The non-market ecosystem services provided by natural capital in the Mackenzie Region contribute over 13.5 times more societal economic value than the GDP generated by natural capital extraction industries.
- Using an assumption of a 50% loss in ESP values from the cumulative industrial footprint, an estimated net loss in potential ESP value of $19 billion in 2005.
- The total combined value for GDP and ESP, adjusted for ecological depreciation using an assumption of a 50% loss in ESP, yields a total ecological-economic product estimate of $574.5 billion. Report concluded that using this example, the benefits of natural capital extraction in GDP came at an ecological depreciation cost of $19 billion in 2005.

Krantzberg, G., and de Boer, C. 2006. *A Valuation of Ecological Services in the Great Lakes Basin Ecosystem to Sustain Healthy Communities and a Dynamic Economy*. Dafasco Centre for Engineering and Public Policy. McMaster University. Hamilton, Ontario. (prepared for the Ontario Ministry of Natural Resources.

Values/Outcomes Reported

- Commercial Fishing and aquaculture
    - In 2005, the commercial fishery industry was worth $35 million in landed value of fish alone in Ontario; $91.4 million including indirect sales, employment income and taxes and person-years of work.
    - Aquaculture worth $23-$24 million in landed value of fish; $65 million in total value added to Ontario's economy.
- Transportation
    - $2.2 billion to $3 billion plus 17,000 Canadian jobs in value added to provincial GDP (Great Lakes & St. Lawrence).
- Recreation
    - Sport Fishing $7.5 billion in value of total industry including money spent on trips, boats, travel and tourism (Canada and U.S.).
    - Direct spending on sport fishing on trips only in Ontario $500 million.
    - Recreational boating worth $2.2 billion to the Canadian economy.
    - Beaches worth $200 million to $250 million as valued by beach-goers in terms of what they would be willing to spend to recreate at the beach (Ontario). Based on an average day at the beach worth $35 to an individual.
    - Wetlands and biodiversity worth $70 billion to the Canadian economy including nutrient cycling, flood control, climate control, soil productivity forest health, genetic vigour, pollination and pest control. Value is based on an estimate from a 2006 National Round Table on the Environment and Economy study.
- Water Infrastructure
    - Riparian zone values include stormwater treatment. The costs of engineered stormwater best management practices range from $200 to $4,000 per hectare with a lifetime of about 20-25 years.
    - Reports on a study that found more compact and efficient urbanization in the Greater Toronto Area would save about $12.7 billion to $20.4 billion (in 2007) in infrastructure costs and about $3.2 billion to $5.1 billion in operating and maintenance costs over 25 years.

Canadian Urban Institute. 2006. *Nature Counts: Valuing Southern Ontario's Natural Heritage*. Toronto, Canada (prepared for the Ministry of Natural Resources – Natural Space Program).

Values/Outcomes Reported

- Private Land Forestry
    - approximate total economic activity generated by forestry in southern Ontario, including direct, indirect and induced effects, is $2.7 billion, of which private land forestry constitutes 64 percent, or $1.7 billion.

- net economic contribution represented in terms of value added, is estimated to be almost $1.2 billion, with private land resources contributing two-thirds of the impact.
- Employment in logging, wood and paper industries in southern Ontario connected directly to private land resources is estimated to be almost 11,000, but is closer to 60,000 when value-added economic impact is included. The total federal, provincial and local tax contribution of this sector is estimated to be $275 million.

- Alternative and Renewable Energy
  - A report prepared for the Ontario Power Authority (OPA) suggests there is about 5,300 MW of developable wind energy potential in southern Ontario.
  - Depending on the price of energy, one MW turbine could provide a landowner with an income of $2,500.00 per year from leasing the land.
  - Southern Ontario has about 140 MW of waterpower potential remaining. About 30 of these sites are classified as small (1 MW to 10 MW) 150 are mini (100 KW to 1 MW) and more than 400 are micro (100 KW or less).
- Nature's Health Benefits
  - the presence of natural areas encourages people to interact more with their community, and is linked with lower crime rates and reduced aggression by prison inmates. Research has also documented the that hospital patients recover faster if they can see greenspace and workers are more productive and report greater job satisfaction if they can see nature.
  - relationship between a healthy environment and interaction with nature can reduce the costs of health care. For example, greenspace plays a key role by helping to keep people active and healthy. The "Green Gym", a program in the United Kingdom found that situating exercise programs in a natural setting improves the success rate for participants, not only in terms of their performance but also with respect to sustaining ongoing interest in exercise programs, their spiritual well-being and their appreciation of quality of life. The resulting health benefits include reduced hypertension, cardiovascular disease, osteoporosis and other diseases.
  - the treatment of childhood diseases has also been linked to time spent in natural areas. Children exposed to nature exhibit fewer symptoms of Attention Deficit Disorder than those whose environment does not include open space, trees or some other example of natural space.

- Tourism
  - province-wide revenues for the industry reached $ 21.4 billion with provincial tax revenues from tourism reaching $2.4 billion and municipal tax revenues adding up to $198 million (2004/05).
  - one in five businesses in Ontario is a tourism related business.

  - visitors to Ontario's Parks supported a value-added total of $377.4 million and a gross total output of $705.4 million as well as supporting $247.5 million in wages and salaries, 7,316.5 person years of employment., and

$125.6 million in provincial, federal and municipal taxes according to *The Economic Impact of Ontario Parks*.

Duwors, E. et al. 1999. *The Importance of Nature to Canadians: The Economic Significance of Nature-Related Activities*. Environmental Economics Branch. Environment Canada. Ottawa, Canada.

Values/Outcomes Reported

Survey Results

- In 1996, 20 million Canadians spent $11.0 billion in Canada to pursue nature-related activities on trips or around their homes.
- Of the total expenditures, 28.4 per cent was spent on equipment used primarily for nature-related activities, 23.5 percent was spent on transportation, 18.4 percent on food, 12.7 percent on accommodation and 5.8 percent on other items such as entry fees. The remaining 11.2 percent was spent on other nature-related activities.
- Canadians spent $7.2 billion on outdoor activities in natural areas, $1.3 billion for wildlife viewing, $1.9 billion for recreational fishing, over $800 million for hunting and $1.2 billion for other nature-related activities including contributions to nature-related organizations, sustaining land for conservation and residential wildlife-related activities.
- A survey by the U.S. Fish and Wildlife Service estimated that U.S. visitors to Canada for two nature-related activities - wildlife viewing and recreational fishing - spent over $700 million. The total would be even higher if it were to include spending by U.S. visitors in Canada for other nature-related activities, such as sightseeing, camping, boating and hiking.

Economic impacts

- the $11.7 billion spent in Canada on nature-related activities by Canadians and U.S. visitors led to contributions of $17.3 billion to gross business production and $12.1 billion to Canada's gross domestic product (GDP), $5.9 billion in personal income generated by the 215,000 jobs that were sustained by this economic activity, and $5.4 billion in government revenue from taxes.
- The report presents a breakdown by province and territory of the above estimates.
- Survey participants indicated that they would have spent an additional $2.0 billion before deciding not to participate in nature-related activities in 1996. This represents the economic value that participants place on nature-related activities.

9.2 Watershed, Wetland and Water Value Studies

Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Centre for Public Policy Research. Simon Fraser University. Vancouver, British Columbia. (Prepared for Ducks Unlimited Canada and The Nature Conservancy of Canada).

Values/Outcomes Reported

- The value of natural capital in the Lower Fraser Valley is estimated to include:
    - Waste treatment services by wetlands – removal of nitrogen and phosphorus ($452 to $1,270/ha/year)
    - Flood protection from wetlands ($408 to $2,110/ha/year)
    - Forests: food harvests, recreational uses ($134/ha/year)
    - Carbon sequestration from forests ($15 to $608/ha/year)
    - Wildlife viewing ($53/ha/year)
    - Hunting and fishing ($36/ha/year)
    - Estuaries ($22,800/ha/year)
    - Lakes and rivers ($8,500/ha/year)
    - Forests ($2,000/ha/year)
    - Grasslands and rangelands ($230/ha/year)

- The agricultural 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,
    - $65/ha/yr in the Upper Assiniboine River Basin in eastern Saskatchewan and western Manitoba, and
    - $126/ha/yr in the Mill River Watershed in P.E.I.

- The report suggests that 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.

- Wetland ecosystems are highlighted in the report because of the diverse services that they provide including:
    - changes that degrade small headwater wetlands and stream systems affect the health and productivity of streams, lakes and rivers downstream.
    - Wetlands are natural filters that improve water quality and help neutralize a number of different contaminants. They remove nutrients such as

phosphorus and nitrogen from water flowing into lakes, streams and rivers, as well as groundwater.
    - Wetlands can reduce nitrate and phosphorus up to 80 percent and 94 percent respectively.
    - 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.
    - wetland depressions are important in both groundwater recharge and water storage in many physiographic settings, including the northern glaciated prairies. 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. Forested wetlands overlying permeable soil may release up to 100,000 gallons/acre/day into groundwater.
    - if wetlands are 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.
    - 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. 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. Conversely, when wetlands are destroyed, the probability of a given rainfall event causing flooding and floodwater damage increases significantly.
    - 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.
    - Humans 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.

Ducks Unlimited Canada. 2008. *Impacts of Wetland Loss: Broughton's Creek Watershed, Southwest Manitoba*. Ducks Unlimited Canada and University of Guelph.

Values/Outcomes Reported

- wetland loss between 1968 and 2005 has resulted in the following changes in ecosystem service flows:

    - 31 % increase in area draining downstream (an additional 91 km^2)
    - 18% increase in peak flow within the creek following rainfall
    - 30% increase in stream flow
    - 31% increase in nitrogen and phosphorus load from the watershed
    - 41% increase in sediment loading
    - release of approximately 34,000 tonnes of carbon (125,000 tonnes of CO2e) – the annual emissions of 23,200 cars
    - estimated 28% decrease in annual waterfowl production.

- extrapolated to all of southwestern Manitoba, an area similar to the Broughton's Creek watershed indicates that wetland drainage since 1968 has resulted in:
    - an increase in total phosphorus loading by 114 tonnes per year to Lake Winnipeg (Every year the lake experiences massive algae blooms from increased nutrients resulting from wetland loss throughout the Lake Winnipeg watershed - this amount of phosphorus is the same as dumping 10 semi loads of commercial agricultural fertilizer or 544,000 bags (seven kilograms each) of lawn fertilizer directly into Lake Winnipeg every year.
    - a release of 5 million tonnes of carbon stored in wetland sediments and plant material – equivalent to the emissions of 169,000 cars for 20 years.
    - an increase in area contributing run-off to Lake Winnipeg of 4,518 square kilometres.

- estimated value of wetland ecosystem services associated with nutrient removal and carbon sequestration that have been lost since 1968 is $430 million.
- replacement of the ecosystem services lost in Manitoba in 2005 alone would cost approximately $15 million - will increase to $19 million by 2020 if wetland drainage is not halted.

- did not consider the economic costs of downstream flooding, lost biodiversity, lost groundwater discharge, diminished ecotourism and many other ecological functions that are lost when wetlands are drained or degraded.

Yang, W., Wang, X., Gabor, S., Boychuk, L, and Badiou, P. 2008. *Water Quantity and Quality Benefits from Wetland Conservation and Restoration in the Broughton's Creek Watershed*. Ducks Unlimited Canada. Manitoba, Canada.

Values/outcomes reported

- Six scenarios with total wetland area ranging from 2,379 ha to 2,998 ha were analyzed.
    - peak discharge at the watershed outlet was predicted to decrease by up to 23.4%, and the sediment loading to decrease by up to 16.9%.
    - scenarios with wetland areas between 2,689 and 2,875 ha (i.e., restoration of 310 to 497 ha) were probably most cost-effective.
    - scenarios that had total wetland area equivalent to year 1968, wetland drainage area increased from 47.4% (11,906 ha) to 59.7% (15,009 ha) of the watershed area, whereas, the stream drainage area (i.e., the area

directly drained into the streams) decreased from 52.6% (13,233 ha) to 40.3% (10,130 ha) of the watershed area.

- results demonstrate that the total phosphorus (TP) yield can be reduced by 79 to 785 kg/yr and the total nitrogen (TN) yield can be reduced by 423 to 4,219 kg/yr.
- reductions are equivalent to 2.4 to 23.4% of the existing TP or TN export out of the study watershed.
- extrapolated to the larger Little Saskatchewan River watershed indicated that restoring wetlands in the watershed could reduce the TP yield by 3.4 to 34% (i.e. 992 to 9,892 kg/yr) and the TN yield by 1.9 to 18.9% (i.e. 5,334 to 53,163 kg/yr).

Hotte, N., Kennedy, M., and Lantz, V. 2009. *Valuing Wetland Ecosystem Services in the Credit River Watershed, Ontario: Phase 1 Report*. (March 2009 draft). The Pembina Institute. Drayton Valley, Alberta.

Values/Outcomes Reported

- wetlands are the most productive natural areas in the world; estimated to provide up to 40% of all ecosystem services worldwide, despite covering only 1.5% of the Earth's surface.
- approximately 70% of Prairie and southern Ontario wetlands have been converted for alternative land uses since European settlement.
- 75% of natural wetlands within the Credit River watershed have been lost due to land use conversion.
- rapid shift to an urban landscape is negatively impacting surface and groundwater quality and quantity, streamflow, erosion and wildlife habitat.
- Effects of urbanization include increased area of impervious soils, reduced wildlife habitat, decreased surface water infiltration, increased soil erosion and an overall decline in the amount of groundwater recharge, annual precipitation and streamflow between 2000 -2003.

Waste Treatment

- conserving downstream wetlands can maximize waste treatment benefits and has been observed to reduce nitrate concentrations by up to 80%.
- wetlands provide nitrate- and phosphate-removal benefits, if they feature both deep and shallow areas.
- the ability of wetlands to improve water quality is related to: vegetation cover or type; depth; water retention time; soil type; particle size; and regional climate.
- wetlands should occupy at least 2.83% (+/- 2.71%) of agricultural catchments in order to maintain good water quality in areas with highly saline soils.
- wetlands have been reported to remove approximately 77% of total nitrogen in surface inflows.
- in order for wetlands to have an impact on overall watershed hydrology, they must occupy at least 2% to 7% of the total watershed area

Biodiversity

- wetlands which effectively remove significant amounts of nutrients and sediments are not necessarily high-quality wildlife habitats because they are more likely to develop monocultures of hardy, nutrient-loving plant species such as cattails
- large wetlands are more valuable for preserving avian biodiversity than smaller wetlands, especially when they are located next to large tracts of upland habitat; biodiversity may be equaled in small wetlands with significant structural diversity, canopy layering or productivity .
- Nature Conservancy's guideline of 15-25% of an area must be conserved in order to protect biodiversity.
- Habitat connectivity and structural diversity are significant factors required to enhance biodiversity.
- Periodic natural disturbance within a normal disturbance pattern due to events such as flooding is also required to maintain biodiversity
- Fragments of natural habitats provide the best opportunity to stimulate biodiversity

Climate Regulation

- carbon comprises roughly 50% of plant biomass. Therefore, carbon storage is proportionate to the amount of plant biomass, which can be calculated as the density of plant vegetation multiplied by wetland area and depth of accumulated decaying vegetation or peat.

Flood Control

- data indicates that wetlands must occupy at least 10% of a watershed in order to provide flood protection (only 6% of the Credit Valley watershed is currently occupied by wetlands)
- small wetlands located high in a watershed are beneficial for diminishing flood volume and delay peak flows
- large wetlands located downstream reduce total peak flow volume
- Flood mitigation also depends on each wetland's individual evapo-transpiration and infiltration rates and residence time
- most wetland services increase with wetland area including fisheries productivity and stream flow maintenance, which are directly proportional to wetland area
- carbon storage is proportional to both wetland area and depth, and some services, such as preservation of biodiversity, estimated as species richness commonly increase exponentially with area.

Recreation Benefits

- Recreational use of wetlands includes fishing, hiking and birdwatching
- biodiversity is a key factor influencing wetland recreational use.

Aesthetic Benefits

- wetland aesthetics are typically associated with residential landowners who may derive some benefit from viewing the wetland.
- presence of open water, wetland shape and total wetland surface area are known to influence aesthetics.

Impacts of Pollution

- Pollution is one of the leading factors that influence the ability of wetlands to perform ecosystem functions
- a critical threshold for phosphorus loading is 1 mg P/m2/year for North American wetlands. Above this threshold, uptake and removal of nutrients by wetland plants is severely impeded
- Excessive phosphorus loading is known to cause colonization of waterways by algae and other aquatic plants, leading to eutrophication, depleted dissolved oxygen and subsequent impairment of a variety of ecological services
- Land clearing and resulting sedimentation can increase turbidity and biological oxygen demand and impede wetland function.
- the Conservation Authorities Act mandates a 120 m buffer around wetlands to prevent impact to ecological function; however, exemptions can be made for agricultural or other land uses.
- when more than 80-90% of a watershed's natural wetlands have been drained, the
- risk of flooding and eutrophication of local water bodies increases significantly
- Climate change will also impact wetland function by reducing the water table in dry areas, leading to increased carbon dioxide production, lower methane fluxes and lower dissolved oxygen fluxes

Gardner Pinfold Consulting Economists Limited. *Natural Capital – An Economic Valuation of Water as an Input to the Alberta Economy. (Draft report; not yet released)* Prepared for the Government of Alberta and Government of Canada.

9.2.1.1 Values/Outcomes Reported

The estimated overall value for water in the South Saskatchewan River Basin as an input to the economy in 2004 is reported to be just over $1 billion. However, this estimate underestimates the true value because data gaps restrictions. In some cases minimum values are used and in other cases no estimation was provided because of a lack of data.

Values
Agricultural production total estimated $204 million; total water use was estimated at 2.9 billion cubic metres

- water in crop production is $198.9 million
- water in stock watering $4.3 million
- water in greenhouse production about $500,000

Domestic use estimated $460.4 million; water consumption about 212 million cubic metres

- Includes municipal households, farm households and rural non-farm households
- Total value includes about $229.5 million in actual expenditures and about $230.9 million in additional willingness to pay value

Commercial and institutional use is estimated total $42 million; 77 million cubic metres

- Total estimated willingness to pay $20.9 million
- Actual expenditures on water estimated to be $21 million

Industrial water use estimated 344.5 million cubic metres in 2004 worth an estimated $138 million

- Largest user is chemical industry, followed by petroleum products, paper and allied products and food processing

Water use for oil, gas and mining extraction estimated to be $13.3 million

- Total water use measured as water intake was 26.4 million cubic metres of water intake in 2004
- largest water user is oil and gas extraction

Hydro power generation estimated value of $38.4 million for water use

- mid-range value between estimated value of the low cost alternative production and the estimated value of the high cost alternative (gas $53.6 million)
- hydroelectric power generation water use is generally considered non-consumptive

Estimate value for water in thermal electricity production was about $78 million

- Total water intake at the two thermal plants was 113.5 million cubic metres
- Water value was estimated as the cost differential between coal and gas-turbines assuming that the latter would be used to replace the former if the water used was not available

The value of water-based recreation activities is based on recreational fishing estimated to be worth about $15.4 million or about $13.50 per rod day fished

- Recreational water activities are an indirect use of water since they use the water but they do not consume it and the water involved remains available for other uses
- Recreational fishing was the only activity that could be estimated
- Additional values for kayaking, rafting, swimming, boating, water fowl hunting and viewing etc.

Total estimated value for passive uses was $21.5 million or about $33 per household for over 640,000 households in study area

- mid-range value among possible in-stream flow related values identified by the extensive literature review
- includes existence value, bequest value and option value, none of which include direct or indirect use of water

Ecosystem services were recognized as having significant value but were not assigned a value

Important data gaps

- Need information on the actual amount of water used irrigating various crops
- Updating the most recent water use and cost information on industrial use of water covering industrial and oil and gas, mining and mineral activities which date from 1996

- Addressing need to develop accurate on amount of participation in recreation activities and value attached to participation by participants
- Developing better understanding of relationship between ecosystem services and related recreational activities and passive use water values
- Maintaining current information in the Environment Canada Municipal Use Database (MUD) will be important to keep domestic and commercial values current

Voora, V., and Venema, H.D. 2008. *An Ecosystem Services Assessment of the Lake Winnipeg Watershed. Phase 1 Report – Southern Manitoba Analysis*. International Institute for Sustainable Development. Winnipeg, Manitoba.

Values/Outcomes Reported

This study focused on the Souris, Red and Assiniboine watersheds that are part of the Lake Winnipeg Watershed. These areas, which contribute about 60 per cent of the overall phosphorus load to the lake, were once a mosaic of forest, native prairie and wetlands, but have largely been cleared and drained for agriculture. The study shows that the value of the pre-settlement landscapes on an annual basis would have provided between $500 million and $3.1 billion of ecosystem services, and between $80 million and $1.4 billion worth of carbon offsets in the emissions market.

The ecosystem services of the Red, Assiniboine and Souris River system were assessed and valued by mapping the land covers of the current and pre-settlement landscapes. Three pre-settlement landscapes were constructed by linking soil genesis information with land cover likelihood. Surface areas for each land cover type were determined for the four landscapes examined, which provided the biophysical basis for assessing the environmental assets and associated ecosystem services.

The assessment determined that the current landscape provides ecosystem service values (ESVs) ranging from CDN$0.33 to 1.03 billion/year, while pre-settlement landscape estimations provide ESVs ranging from CDN$0.5 to 3.02 billion/year. ESVs provided by forests and wetlands account for 79 to 96 per cent of the total ESVs by land cover. Ecosystem services influencing climate change and water quantity and quality, account for 74 to 91 per cent of total ESVs by contextual relevance. To compare similar sets of ESVs, one must evaluate the high or low values between the current and pre-settlement landscapes as they were compiled differently. The important benefits received from forests and wetlands and ecosystem services influencing climate change and water quantity and quality point to a potential opportunity for mitigating environmental issues, such as the degradation of Lake Winnipeg's water quality, by preserving and restoring environmental assets on the landscape. The table below summarizes the ESVs calculated.

Wilson, S.J. 2008. *Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services*. Lake Simcoe Region Conservation Authority and the Greenbelt Foundation. Ontario, Canada.

Values/outcomes reported

The land and water cover for the watershed was reported using ELC (Ecological Land Classification) database. Agricultural lands are the predominant land cover in the basin. Intensive agricultural lands total 63,303 hectares, including 4,166 hectares of market gardens, 49 hectares of orchards, 56,085 hectares of row crops, 2,131 hectares of sod, and 869 hectares of tree farms. Non-intensive agricultural lands cover 57,347 hectares 32,899 hectares of hay fields and 24,446 hectares of pasture.

Total forest area is 66,379 hectares, which includes treed swamp, coniferous forest, deciduous forest, mixed forest and plantations. Wetlands cover 38,974 hectares including swamp, marsh, shallow water with vegetation, fen, and shrub bogs. Grasslands cover a much smaller area of 8,353 hectares, which mostly consists of cultural meadows. All of these cover types add up to 90,313 hectares of natural cover (27 per cent) in the Lake Simcoe basin.[34] In addition, water (e.g. lakes, rivers and streams) covers 72,141 hectares of the watershed.

The total annual value of the watershed's non-market ecosystem services is reported as $975 million, an average $2,948 per hectare per year . The ecosystem services attributed with the highest value per hectare are habitat, flood control, recreation, waste treatment, climate regulation, and pollination (see Table 1).

Table 2: Summary Table of Lake Simcoe Watershed Ecosystem Service Values by Ecosystem Service

Ecosystem Service	**Total Value (million$/year)**
Air Quality	**$25.77**
Climate regulation (stored)	**$145.54**
Climate regulation (annual sequestration)	**$4.04**
Flood Control (wetlands)	**$123.48**
Water regulation (control of runoff - forests)	**$30.56**
Water filtration & supply network	**$40.57**
Erosion control and sediment retention	**$0.58**
Soil formation	**$1.98**

[34] The total natural cover area is less than the three cover types added total because treed swamp cover is counted and classified as both forest and wetland, but only counted once in total natural cover area.

Nutrient cycling	**$0.67**
Waste treatment	**$69.56**
Pollination (agriculture)	**$97.99**
Natural Regeneration (Seed dispersal)	**$35.63**
Habitat/Refugia	**$178.28**
Recreation & Aesthetics	**$220.53**
Total value	**$975.16**

By land cover type, the highest values per hectare are attributed to wetlands and forests (see Table 2). Wetlands are worth an estimated $435 million per year ($11,172/hectare) because of their high value for water regulation, water filtration, flood control, waste treatment, recreation, and wildlife habitat. Forests provide $319 million per year because of their importance for water filtration services, carbon storage services, habitat for pollinators, wildlife and recreation. Water bodies provide services worth $103 million per year including the natural infrastructure for carrying and transporting water as well as recreational values. Agricultural lands total value is also substantial at an estimated $93 million per year including cropland, pasture, hedgerows and cultural woodland.

Table 3: Summary Table of Lake Simcoe Watershed Ecosystem Service Values by Land Cover Type

Land Cover Type	**Area (hectares)**	**Value per hectare ($/hectare/yr)**	**Total Value ($Million/yr)**
Forest	66,379	$4,798	$319
Grasslands	8,353	$2,727	$23
Wetlands	38,974	$11,172	$435
Water	72,141	$1,428	$103
Cropland	96,202	$529	$51
Hedgerows/Cultural Woodland	3,855	$1,453	$5.60
Pasture	24,447	$1,479	$36
Urban Parks	3,363	$824	$2.77
Total	330,741	$2,948	$975

The ecosystem service values by ecosystem service and land cover type are shown in Table 3.

Table 3: Summary Table of Ecosystem Services for the Lake Simcoe Watershed by Ecosystem Service and Land Cover Type

	Forest	Grass lands	Wetlands					Water	Agricultural lands			Urban	**Total (M$/year)**
Ecosystem Service Functions	**Cool temperate**		**Shallow Water**	**Bog**	**Marsh**	**Swamps**	**Fen**	**Open Water**	**Cropland**	**Pasture**	**Hedgerows / Cultural woodland**	**Urban Recreational Areas**	Total Value for all cover types
Gas regulation/Air Quality	$377	$12										**$189**	**$25.77**
Climate regulation (stored carbon)	$919	$438	$623	$969	$714	$524	$1,302		$523	$464	$438		**$145.54**
Climate regulation (annual carbon sequestration)	$39	$28	$13	$13	$13	$13	$13			$28	$28		**$4.04**
Disturbance regulation			$4,039	$4,039	$4,039	$4,039	$4,039						**$123.48**
Water regulation	$459	$7										$20	**$30.56**
Water supply (filtration)	$210		$407	$407	$407	$407	$407	$197					**$40.57**
Erosion control and sediment retention		$50								$6	$6		**$0.58**
Soil formation	$17	$10							$6	$6	$6		**$1.98**
Nutrient cycling										$24	$24		**$0.67**
Waste treatment	$58		$2,148	$2,148	$2,148	$2,148	$2,148						**$69.56**
Pollination (agri)	$951	$951								$951	$951		**$97.99**
Natural Regeneration (Seed dispersal)	$537												**$35.63**

Biological control													
Habitat/ Refugia			$5,831	$5,831	$5,831	$5,831	$5,831						**$178.28**
Genetic resources													**$-**
Recreation & Aesthetics	$1,231	$1,231	$1,231	$1,231	$1,231	$1,231	$1,231	$1,231				$616	**$220.53**
Cultural/ Spiritual													**$-**
Total per hectare $/hectare/year	$4,798	$2,727	$14,292	$14,637	$14,382	$14,193	$14,971	$1,428	$529	$1,479	$1,453	$824	**$2,948.42**
Area (ha)	66,379	8,353	1,778	25	4,925	23,393	455	72,141	96,202	24,447	3,855	3,363	330,741
Total value $M/yr	$318.5	$22.8	$25.4	$0.4	$70.8	$332.0	$6.8	$103.0	$50.9	$36.2	$5.6	$2.8	$975.2

Ecosystem services were reported by land and water cover type. The total value by ecosystem service values is shown in Table 4.

Table 4: Summary Table of Lake Simcoe Watershed Ecosystem Service Values by Ecosystem Service

Ecosystem Service	**Total Value (million$/year)**
Air Quality	**$25.77**
Climate regulation (stored)	**$145.54**
Climate regulation (annual sequestration)	**$4.04**
Flood Control (wetlands)	**$123.48**
Water regulation (control of runoff - forests)	**$30.56**
Water filtration & supply network	**$40.57**
Erosion control and sediment retention	**$0.58**
Soil formation	**$1.98**
Nutrient cycling	**$0.67**
Waste treatment	**$69.56**
Pollination (agriculture)	**$97.99**
Natural Regeneration (Seed dispersal)	**$35.63**
Habitat/Refugia	**$178.28**
Recreation & Aesthetics	**$220.53**
Total value	**$975.16**

Other Findings

- Wetlands are critical for watershed functions and services, however, wetlands have declined by about 70 per cent in southern Ontario over the past century. As they become scarcer, their presence and services have become more valuable.

9.3 Protected Area Studies

Voora, V. and Barg, S. 2008. *Pimachiowin Aki World Heritage Project Area Ecosystem Services Valuation Assessment*. International Institute for Sustainable Development. Winnipeg, Manitoba.

9.3.1.1 Values/Outcomes Reported

The study first developed a land cover inventory and map of the area showing the area of land cover and land use types. Ecosystem services values were compiled from available statistics and from recognized ecosystem valuation studies conducted earlier in similar areas. Therefore, the main approach for valuation is benefits transfer where values are transferred from previous studies.

This study reports the benefits to people living on the land and people living away from the area. The study findings show that residents of the area receive $32 million in direct benefits, whereas non-residents or visitors get about $12 million in benefits, and shared benefits range from $75 to $85 million. Together the total benefits are estimated to range from $121 to $130 million.

The largest components of this estimate are fishing (at $35 million/year), pure water ($32 million/year) and carbon sequestration (between $12 and $21 million/year). This estimate is conservative, as a number of the ecosystem services identified were not valued due to a lack of information.

Table 5 shows the ecosystem service values that the study was able to determine based on the authors research. The benefits are provided for residents and non-residents.

Table 5: Ecosystem Service Values for the Pimachiowin Aki World Heritage Project Area

Conservative ecosystem service economic values provided by the proposed World Heritage Site (all economic values in CDN$ million/year)

Ecosystem Service	Resident	Non-Resident	Total
Provisioning	32.22	7.03	59.42
Hunting activities	2.59	0.98	3.57
Fishing activities	29.05	6.05	35.10
Wild rice harvesting	0.38	0	0.38
Water supply	0.13	0	0.13
Medicinal plants	-	0	-
Trapping	0.07	0	0.07
Hydro-power	-	-	20.17
Regulating	0.02	-	47.52–56.47
Carbon sequestration	-	-	12.32–21.27
Air filtration	0.02	-	0.02
Micro-climates	-	-	-
Water treatment	-	-	31.83
Erosion control	-	-	3.35
Flood prevention	-	-	-
Biological control	-	-	-
Cultural	-	5.33	5.33
Recreational opportunities	0	3.05	3.05

Spiritual and religious	-	-	-
Cultural heritage	-	2.28	2.28
Educational experiences	-	-	-
Supporting	-	-	9.08
Pollination	-	-	-
Habitat/refugia	-	-	9.08
Soil formation	-	-	-
Totals	32.24	12.36	121.35–130.30

In addition, some ecosystem service values were calculated and omitted from the site's overall ecosystem service value because they were based on studies from areas with greater populations. However, a summary of these other potential ecosystem service values is provided in the report. These values include services such as water supply, air filtration, flood prevention and cultural values.

Potential ecosystem service economic values provided by the proposed World Heritage Site (all economic values in CDN$ million/year)

Ecosystem service	Resident	Non-resident	Total
Provisioning	-	-	*270–5,550*
Water supply	-	-	270–5,550
Regulating	-	-	*730–980*
Air filtration	-	-	350–600
Flood prevention	-	-	380
Cultural	*0.16*	-	*0.16*
Spiritual and Religous	0.16	-	0.16
Totals	*0.16*	-	*1,000.16–6,530.16*

The carbon stored within the forests and peatlands of the study area was also estimated but it too was not included in the annual overall total because it was not considered as annual revenue. The value was estimated to be approximately CDN$2.70 to $17.51 billion.

Kulshreshtha, S. and Johnston, M. 2000. *Economic Value Of Stored Carbon In Protected Areas: A Case Study Of Canadian National Parks*. University of Saskatoon. Saskatoon, Saskatchewan.

Values/Outcomes Reported

The authors chose two alternative values of stored carbon based on the substitute cost and replacement cost methods. The substitute cost was estimated at $17.50 per tonne of carbon sequestered. For the replacement cost method, the cost per tonne of carbon sequestered under natural regeneration was estimated at $12.50, whereas for the artificial reforestation, doubling of the cost is typical, leading to a weighted average cost of $16.25 per tonne.

Using the two values of carbon, ($17.50 for substitution Cost and $$16.25 for replacement cost), the value of national parks for carbon sequestration is estimated between $72 and $78 billion. On average, it was estimated that the National Park lands are worth $2,967 per hectare, ranging from a low of $202 in the Yukon Territory, to a high $8,413 per ha in Saskatchewan.

Sensitivity analysis indicated a wider range in the value of stored carbon. At the low range of values, total value of national parks for carbon sequestration is estimated to be $11.8 million. It should be noted that this is value of the total stock of carbon in the various pools, and not an annualized value. Under the price of $500 per tonne of carbon stored, national parks are very valuable to Canadian society. Their value can be as high as $2.2 trillion.. On a per hectare basis, the range in the value is from $452 to $84,781. National parks located in the western and northern parts of Canada reported greater per hectare value.

Wilson, S.J. 2008. *Ontario's Wealth, Canada's Future: Appreciating the value of the Greenbelt's eco-services*. David Suzuki Foundation. Vancouver, BC.

Values/outcomes reported

The total value of southern Ontario's Greenbelt by ecosystem service is reported in Table 6.

Table 6: The Value of Southern Ontario's Greenbelt Ecosystem Services

Ecosystem Service	**Total Value ($)**
Air quality	$68,868,821
Climate regulation (stored carbon)	$366,451,342
Climate regulation (annual carbon uptake)	$10,982,151
Flood control (wetlands)	$379,676,010
Water regulation (control of runoff – forests)	$278,103,520
Water filtration	$131,107,489
Erosion control and sediment retention	$532,417
Soil formation	$6,005,164
Nutrient cycling	$2,141,547
Waste treatment	$294,360,279
Pollination (agriculture)	$298,235,257
Natural regeneration	$98,001,705
Biological control	$8,175,746
Habitat/Refugia	$548,184,172
Genetic resources	n/a
Recreation and aesthetics	$95,207,535
Cultural (agricultural)	$65,674,796
Total value ($/year)	$2,651,707,951

The non-market ecosystem service values per hectare for each land cover type are shown here in Table 7

Table 7: Non-Market Ecosystem Services by Service and Land Cover Type in the Greenbelt

	Forest	Grasslands	Wetlands					Water		Agricultual Lands			
Ecosystem Service Functions	**Cool temperate**		**Open Water**	**Bog**	**Marsh**	**Swamps**	**Fen**	**Rivers**	**Beach/ Dunes**	**Cropland**	**Idle Land**	**Hedgerows**	**Orchards**
Air Quality	$ 377.14	$ 12											
2a. Climate regulation (stored carbon)	$ 919	$ 213	$ 676.59	$ 486.09	$ 539.61	$ 429.41	$ 1,360.35			$ 332.54	$ 316.75	$ 327.57	$ 298.11
2b. Climate regulation (annual carbon uptake)	$ 39.11	$ 28.46	$ 13.02	$ 13.02	$ 13.02	$ 13.02	$ 13.02				$ 28.59	$ 28.59	$ 28.59
Flood Control			$ 4,038.51	$ 4,038.51	$ 4,038.51	$ 4,038.51	$ 4,038.51						
Water regulation (runoff control)	$ 1,523	$ 7											
Water filtration	$ 473.98		$ 473.98	$ 473.98	$ 473.98	$ 473.98	$ 473.98						
Erosion control and sediment retention		$ 50									$ 5.60	$ 5.60	$ 5.60
Soil formation	$ 17	$ 10								$ 6.06	$ 6.06	$ 6.06	
Nutrient cycling											$ 23.50	$ 23.50	$ 23.50
Waste treatment	$ 58	$ 146	$ 3,017	$ 3,017	$ 3,017	$ 3,017	$ 3,017						
Pollination (agriculture)	$ 1,109	$ 1,109									$ 1,109	$ 1,109	
Natural Regeneration	$ 537												
Biological control	$ 25.97	$ 40									$ 39.76	$ 39.76	
Habitat/Refugia			$ 5,830.88	$ 5,830.88	$ 5,830.88	$ 5,830.88	$ 5,830.88						
Genetic resources													
Recreation & Aesthetics	$ 334.73	$ 3	$ 335	$ 335	$ 335	$ 335	$ 335	$ 335	$ 125.00				
Cultural/Spiritual										$ 138.12	$ 138.12	$ 138.12	$ 138.12
Total per ha $/ha/yr	$ 5,414	$ 1,618	$ 14,385	$ 14,194	$ 14,248	$ 14,138	$ 15,069	$ 335	$ 125	$ 477	$ 1,667	$ 1,678	$ 494
Area (ha)	182,594	441	571	578	10,225	82,459	181	7,821	42	384,378	78,889	7,039	5,202
Total value $M/yr	$ 989	$ 0.71	$ 8.2	$ 8.2	$ 146	$ 1,166	$ 2.7	$ 2.6	$ 0.01	$ 183	$ 132	$ 11.8	$ 2.6

The value of the Greenbelt's ecosystem services for each land cover type are provided in Table 8.

Table 8: Ecosystem service values for each land cover type in the Greenbelt

Land Cover Type	Area (hectares)	Value per hectare ($/hectare/yr)	Total Value ($Million/yr)
Wetlands	94,014	$14,153	$1,331
Forest	182,594	$5,414	$989
Grasslands	441	$1,618	$0.714
Rivers	7,821	$335	$2.6
Beach	42	$125	$0.005
Cropland	384,378	$477	$183
Idle land	78,889	$1,667	$132
Hedgerows	7,039	$1,678	$11.8
Orchards	5,202	$494	$2.6
Total	760,420	$3,487	$2,652

The ecosystem service values were also compiled by sub-watershed to establish a total ecosystem value per hectare by watershed. These values were mapped to illustrate the range of values across the Greenbelt. The annual values ranged from $2000/hectare to over $6,000/hectare.

Other Findings

A recent study calculated that air pollution costs Ontario approximately $10 billion each year due to health and environmental damages in southern and central Ontario.[35] Seventy per cent of the total damages ($6.6 billion) are due to health costs, and 30 per cent ($3 billion) are from environmental costs. Ontario's South Central Region, which includes the Greenbelt, incurs a total of $2.1 billion per year due to air pollution, including $4.2 million in health damage costs, $40.8 million in economic losses due to agricultural crop damages, $785 million in economic losses due to visibility reduction, and $270 million in soil damage.[36]

[35] Yap, D., Reid, N., de Brou, G., and Bloxam, R. 2005. Trans-boundary Air Pollution in Ontario. Ontario Ministry of Environment. www.ene.gov.on.ca/envision/techdocs/5158_index.html (accessed Dec. 8, 2007)
[36] Ibid.