Lake Simcoe Basin's Natural Capital:

The Value of the Watershed's Ecosystem Services

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Submitted to: The David Suzuki Foundation,
The Friends of the Greenbelt Foundation
& The Lake Simcoe Region Conservation Authority

Friends of the Greenbelt Foundation Occasional Paper Series
June 2008

David Suzuki Foundation

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Possibility grows here.

Acknowledgements

Thank you to the *Friends of the Greenbelt Foundation* for providing the grant to undertake the analysis for this study. Thank you also to Faisal Moola and Rachel Plotkin at the *David Suzuki Foundation*, Burkhard Mausberg, Kathy Macpherson, Rebecca McNeil and Shelley Petrie at the *Friends of the Greenbelt Foundation,* and Kim Baker, Rob Baldwin, Michael Dennis, Mike Walters and Pamela Strong at the *Lake Simcoe Region Conservation Authority*, for their interest in pursuing natural capital research and for their respective contributions to the report.

Many thanks to Peter Lee and Ryan Cheng of *Global Forest Watch Canada* for the invaluable spatial analysis and maps they provided, as well as the extra time and effort they put into this project. I would also like to thank the *Lake Simcoe Region Conservation Authority* for the ecological data they provided for this project.

The report benefited from the valuable comments of peer reviewers Mark Anielski of *Anielski Management Inc.*, and Carolyn Schulz, Executive Director of *Ontario Nature*.

Disclaimer

The content of this study is the responsibility of its author and does not necessarily reflect the views and opinions of the *David Suzuki Foundation*, the *Friends of the Greenbelt Foundation*, or the *Lake Simcoe Region Conservation Authority*.

The author made every effort to ensure the accuracy of the information contained in this study at the time of writing. However, the author advises that the study itself and peer review were limited by time constraints. The material should thus be viewed as preliminary.

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1.0 Executive Summary

This study quantifies the natural capital value of the ecosystem goods and services provided by Lake Simcoe's watershed, a section of which is located in Ontario's Greenbelt. At a minimum estimated worth of $975 million per year, the services provided by the watershed are worth $2,780 to each of the 350,000 permanent residents annually. This study represents the first application of this methodology to a watershed in southern Ontario.

Goods and services provided by ecosystems are traditionally undervalued as they go unmeasured by conventional economics. These benefits include storage of floodwaters by wetlands, air pollution absorption, climate regulation, pollination of crops and water filtration, resulting in clean air and water and safe and abundant local food sources. In order to measure the value of these benefits, this study first describes the watershed's natural assets – that is, the extent of the forests, wetlands, grasslands, water bodies, agricultural lands and urban or built-up areas. Then, using market-determined values (e.g. the avoided increased costs of a man-made water filtration service as a proxy for the existing capabilities of a natural system to filter water), the study was able to quantify many of the goods and services that are provided by the watershed.

The most highly valued natural assets are the forests and wetlands, worth $319 and $435 million per year, respectively. The high value for wetlands reflects the many important services they provide, such as water regulation, water filtration, flood control, waste treatment, recreation, and wildlife habitat. Forests provide high value because of their importance for water filtration, carbon storage, habitat for pollinators, and recreation.

Although quantifying the entirety of the watershed's monetary value is challenging, the methodology used and resulting figures represented in this study are a starting point. The estimation of these values in concert with the recent commitment by the Government of Ontario to limit ecological damage to the watershed will help Ontarians more deeply appreciate the importance and urgency of protecting the Lake Simcoe watershed. Residents currently receive the services provided by the watershed for free, but if lost they would have to either pay for these services replaced by manmade infrastructure or risk losing the benefits permanently.

As a plan is developed for the watershed, this study reinforces the importance of ensuring meaningful protection of natural features, including through the implementation of a natural heritage system common to the entire watershed. The ecosystem values in this report can also be a useful tool for other regions to determine the hidden wealth of their respective ecological systems and plan more strategically for healthy and sustainable communities.

2.0 Introduction

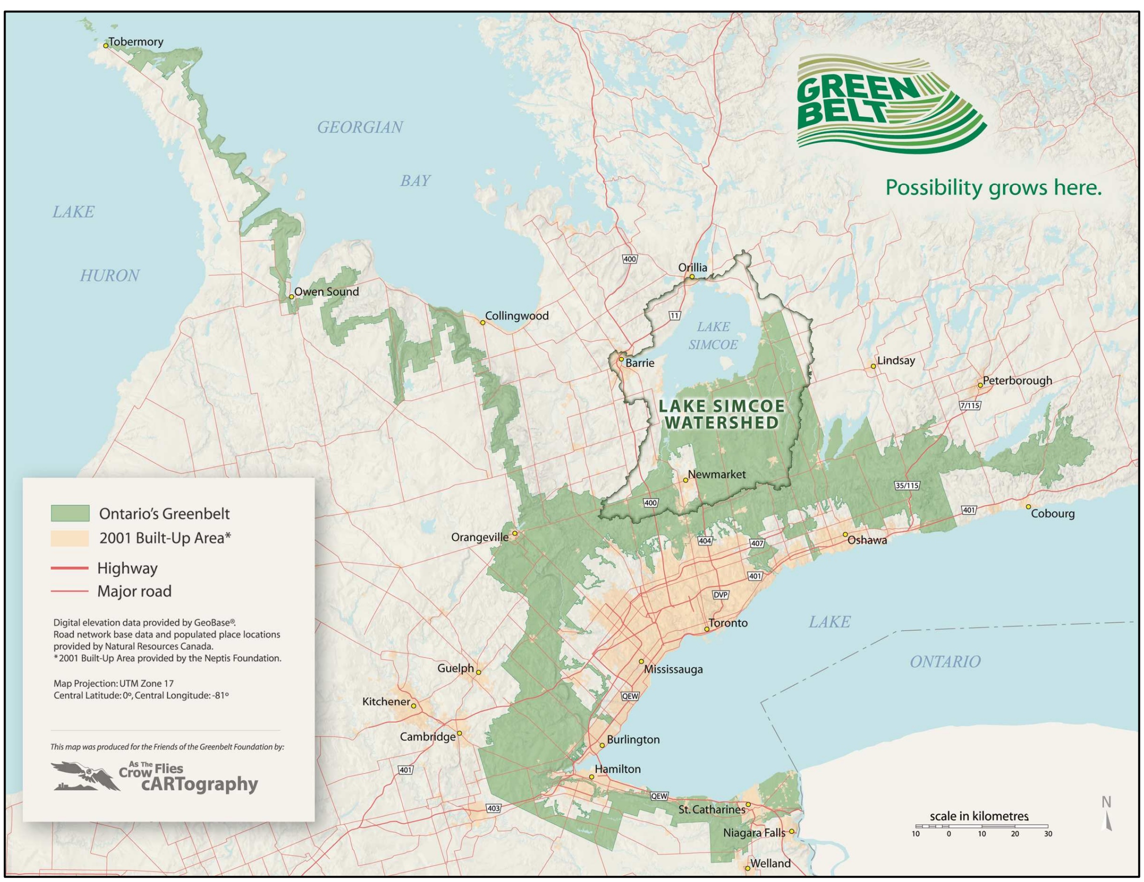
This report is a collaborative from the *David Suzuki Foundation*, the *Friends of the Greenbelt Foundation* and the *Lake Simcoe Region Conservation Authority* to assess the non-market values for the Lake Simcoe Watershed's natural capital. In the following pages, the nature and extent of the watershed's natural capital is described and the value of many of the key non-market ecosystem services is measured.

This report is intended to contribute to evolving work on valuing natural capital and to provide a methodology for valuing it at a watershed and municipal level. By measuring or quantifying the value to communities of ecosystem services, we can more accurately account for land use changes and can thereby help inform land use and other decisions related to altering the landscape.

2.1 Lake Simcoe Watershed

Lake Simcoe is located in central Ontario, within an hour's drive from half the population in Ontario. Aside from the Great Lakes, Lake Simcoe is the largest inland lake in southern Ontario with a surface area of 722 square kilometres. It is also part of the Trent Severn Waterway connecting Lake Ontario to Georgian Bay (Figure 1).

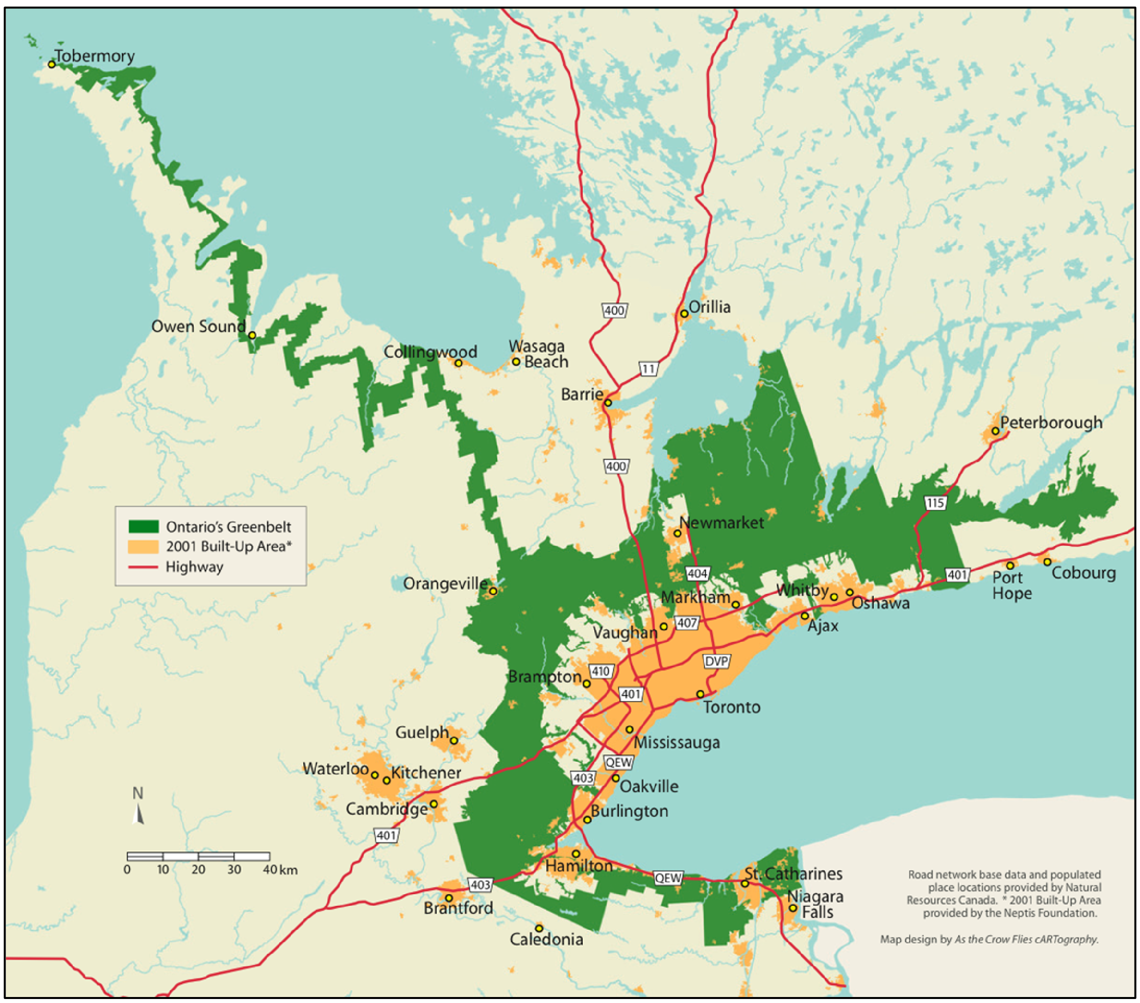
Figure 1: Lake Simcoe Watershed



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) including lands from the north side of the Oak Ridges Moraine through parts of York and Durham Regions, the Cities of Kawartha Lakes, Orillia and Barrie, and the County of Simcoe.

Some of the watershed area (i.e., the Regional Municipalities of York and Durham and a small portion of southern Simcoe County) is part of the provincially designated Greenbelt (Figure 2) under the Greenbelt Act. The Greenbelt Plan provides protection for agricultural lands and the ecological "green infrastructure" that supports the surrounding urban communities. The Greenbelt Plan and the yet to be developed Lake Simcoe Plan will be mutually reinforcing and make for a significant land use protection system.

Figure 2: Provincially Designated Greenbelt



Settled in the early 1800s, the basin is now home to about 350,000 permanent residents with an additional summer population of approximately 50,000. The Lake provides drinking water for municipalities, maintains a significant tourism and recreation industry and hosts agricultural lands, including the Holland Marsh. In particular, the Lake Simcoe basin supports:

- natural heritage features and habitat for many species, including over 32 species at risk;
- 35 tributary rivers (over 3,950 km's of stream channel);
- 5 major tributaries draining north from the Oak Ridges Moraine;
- recreation that generates hundreds of millions of dollars for the local economy surpassing $200 million/annum;
- drinking water supply for eight communities; and
- the assimilation of municipal waste from 14 treatment facilities as well as agricultural run-off.

The Lake Simcoe ecosystem, like all others, is in a constant state of flux. Beginning with its role as an important drainage route for glacial meltwaters, it has witnessed many stages in its development. From the formation of its soils to the development of its plant and animal populations, the Lake Simcoe watershed continues to adapt itself as the landscape is transformed.

Even after the establishment of what is considered a mature landscape some thousand years ago, many natural forces disturbed the ecosystem. To a certain extent, the advent of European settlement has itself disturbed natural cycles of burn and windfall, and replaced them with human activities like logging and agriculture. Although these human activities appear to us to have major consequences in ecosystem function, so might natural forces such as tornadoes, insect pest outbreaks, and forest fires. There is, however, a significant difference. Many human activities, such as draining wetlands or paving over a woodland, have significantly long consequences, while ecosystems restore themselves more easily over time after a natural disturbance occurs.

Natural ecosystems respond to these disturbances with an increase in the loss of water and nutrients from disturbed soils. Sometimes these released materials are themselves necessary to encourage new growth and restore ecosystem equilibrium. However, in the present-day Lake Simcoe watershed, human activities have encouraged and allowed this 'disturbed' condition to persist. The building of subdivisions and tilling the soil has prevented the re-establishment of these natural areas throughout the watershed, so that the watershed is now in a perpetual condition of nutrient, soil and water loss imbalance. If the Lake Simcoe ecosystem is to be sustained, the value of the watershed’s natural features needs to be realized more fully so their relation to human development and natural processes can co-exist. This will help to ensure that the goods and services provided by our natural environment continue into the future.

3.0 Natural Capital and Ecosystem Services

3.1 What is Natural Capital?

Natural capital refers to our natural assets (or "stocks"), and the ecosystem goods and services (or "flows") that those assets provide. Natural assets and ecosystem services are the foundation of life – including human life. The benefits provided by natural capital include the storage of floodwaters by wetlands, water capture and filtration by forested watersheds, air pollution absorption by trees, and climate regulation resulting from carbon storage in trees, plants and soils.

Forests, wetlands and rivers that make up watersheds are like giant utilities providing ecosystem services for local communities as well as regional and global processes that we all benefit from. Ecosystems provide many services including carbon storage and sequestration, water storage, rainfall generation, climate buffering, biodiversity, soil stabilization and more[1]. 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 water.

3.2 Valuing Ecosystems

Ecosystem goods and services 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 species that live within them. Humans are reliant on the capacity of natural processes and systems to provide for human and wildlife needs[2]. These 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]. The following table provides a list of ecosystem functions, processes and the corresponding ecosystem services (Table 1).

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[1] Global Canopy Programme. http://www.globalcanopy.org/main.php?m=3

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

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

Table 1: Ecosystem Functions, Processes and Services

Functions	Ecosystem Processes	Ecosystem Services
Gas regulation	Role of ecosystems in bio-geochemical cycles (e.g. CO^2/O^2 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: 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.

There are several techniques that have been developed to determine economic values for non-market ecosystem services. These include assessing economic damages, the willingness of individuals to pay for goods and services, and 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. This report uses avoided cost and replacement cost for ecosystem service valuation, as well as contingent valuations 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 estimated values provided are likely a conservative estimate because our knowledge of *all* the benefits provided by nature is incomplete, and because without the earth's ecosystems and resources life would be not be possible meaning that the value of nature is essentially priceless. It is also important to note that the value of natural capital and its services will increase over time, as services such as water supply become increasingly scarce due to global warming and population increase, for example. The valuations of ecosystem services, however, provide an opportunity to rigorously assess the current benefits and the potential costs of human impact.

The ecosystem typology and services presented in this report could be taken one step further by developing and adopting natural capital accounts. Natural capital accounts incorporate the ecosystem service values as well as the physical natural assets and the qualitative state or health of these assets. Improved measurement and monitoring of ecosystem and natural resource use and strong inter-governmental collaboration is required to make such accounts work, but there are several uses for them. The accounts provide an assessment of the current state of a designated area that can then be used to identify the benefits of maintaining natural areas and of restoring degraded lands to functioning landscapes. They can also provide information on the potential impacts of changing land use practices, which can facilitate making decisions that minimize human impacts on ecosystems. Once natural capital accounting is integrated at the policy and planning levels, it is possible to assess and report regularly on the changes in natural capital and ecosystem services by monitoring the amount of natural area that is converted using tools such as orthophoto imagery or municipal records of changes in zoning.

3.3 *The Value of Watershed Protection in New York City*

Studies show that the loss of natural forest cover for other land uses can adversely affect freshwater supplies. The protection of watersheds and water sources is key for regulating water supply and water quality.[4]

The most famous example that demonstrates the value of watersheds is the Catskill/Delaware watershed and the water it supplies to New York City. In the early 1990s, the Environmental Protection Agency introduced new requirements for public water systems.[5] City managers determined that a new filtration system would cost US$6 to $8 billion to build and another US$300 million annually to operate.[6] The alternative was a comprehensive watershed protection program including land purchase, pollution reduction and conservation easements that would allow the natural ecosystems to continue to purify the water. The cost for this program was estimated between US$1 billion and US$1.5 billion.

New York City chose to invest in the natural ecosystem services of the watershed rather than building new infrastructure because protecting the watershed had a better rate of return (90 to 170 per cent) and a shorter payback period of four to seven years.[7] The complex network is the largest unfiltered surface water supply in the world, supplying 1.3 billion gallons of water each day.[8] The watershed has provided clean water for New York City since 1915, without the need for filtering.

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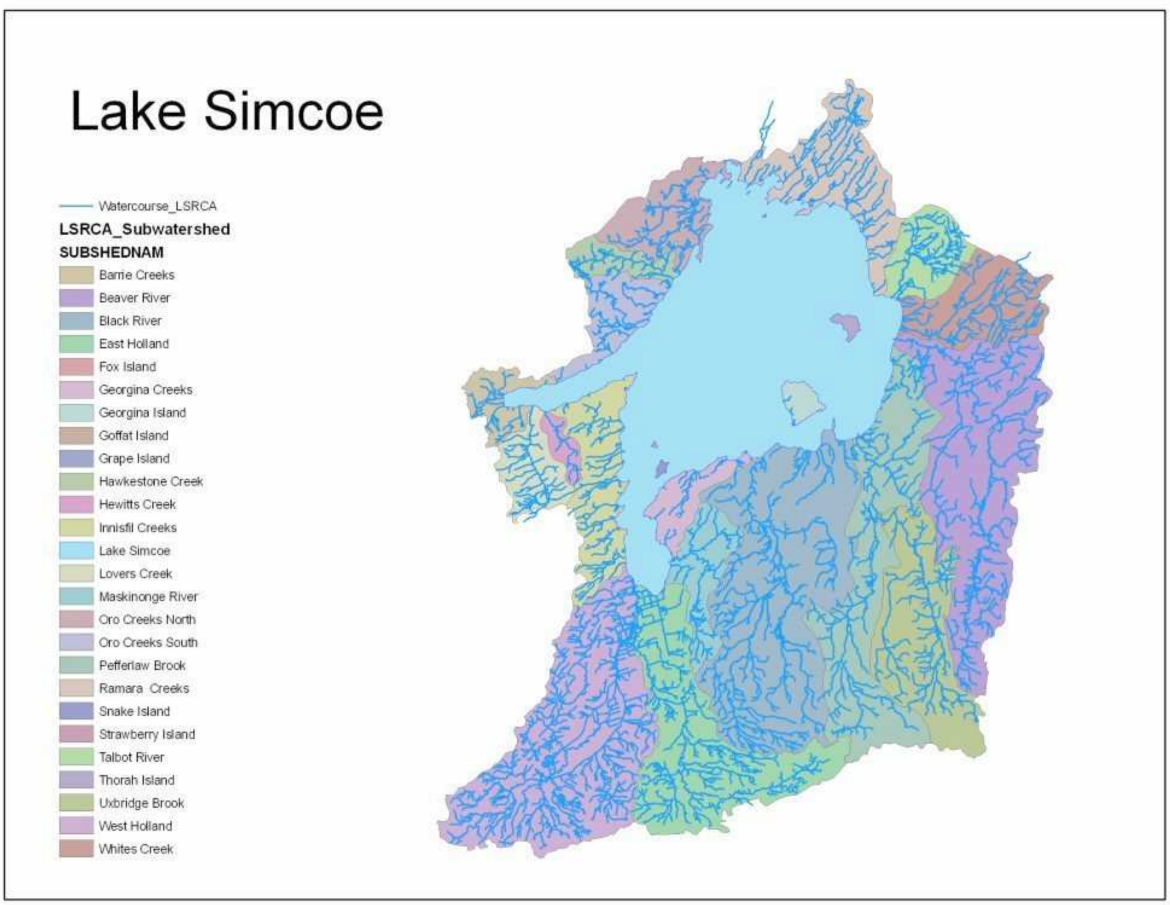
[4] Ernst, C., Gullick, R., and Nixon, K. 2004. "Protecting the Source: Conserving Forests to Protect Water." *Opflow*. 30:1,4-7. American Water Works Association; Food and Agriculture Organization of the United Nations (FAO). 2003. State of the World's Forests, 2003. http://www.fao.org/english/newsroom/news/2003/14880-en.html (accessed Feb. 2008)
[5] NYC Department of Environmental Protection. 2006. *2006 Long-term Watershed Protection Program*. Prepared by the Bureau of Water Supply. NYCDEP.
[6] Richmond, A., Kaufmann, R.K., and Myneni, R.B. 2007. "Valuing ecosystem services: A shadow price for net primary productivity." *Ecological Economics*. 64: 454-462.
[7] Ibid.
[8] NYC Watersheds Water Supply History. http://nyc.gov/html/dep/html/watershed_protection/html/history.html

4.0 Lake Simcoe Land and Water Cover

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.

The Lake Simcoe watershed is 3,307 square kilometres of which the lake occupies about 20 percent or 722 square kilometres. The land portion of the watershed is approximately 2,581 square kilometres and is drained by 35 tributary rivers, with five major tributaries accounting for over 60 percent of the total area. Most of these rivers originate along the southern boundary of the watershed in the Oak Ridges Moraine. These rivers then drain in a northerly direction discharging to Lake Simcoe.

Figure 3: Lake Simcoe Watershed and Sub-watershed Systems



Land cover 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 (details can be found in Appendix A).

Table 2 lists the major land use types in the Lake Simcoe watershed: agricultural land (40 per cent), water (22 per cent), forests (20 per cent), and wetlands (12 per cent). Other lands or land use include urban or built-up areas (9 per cent), grasslands (3 per cent), transportation (2 per cent), and pits and quarries for extraction of resources (0.7 per cent).

Table 2: Lake Simcoe Watershed Land and Water Cover (Ecological Land Classification – ELC)[9]

Land Cover	Land Cover Type	Area (ha)	Percent Cover (%)
Forest			
	Coniferous Forest	4,317	1%
	Mixed Forest	14,797	4%
	Deciduous Forest	18,774	6%
	Treed Swamp[10]	23,393	7%
	Plantations - Tree Cultivated	5,098	2%
	Total	66,379	20%
Wetlands			
	Swamp	31,791	10%
	Fen	455	0.1%
	Shrub Bog	25	0.0%
	Marsh	4,925	1%
	Shallow Water	1,778	0.5%
	Total	38,974	12%
Grasslands			
	Open Tallgrass Prairie	3	0.001%
	Cultural Meadow	8,324	3%
	Meadow-Alvar Forb	27	0.01%
	Total	8,353	3%
Total Natural Cover		90,313	27%
Water Bodies			
	Open Water	72,141	22%
	Total	72,141	22%
Agricultural Lands			
	Intensive Agriculture	63,303	19%
	Non-intensive agriculture	57,347	17%
	Hedgerow/ Cultural woodland	3,855	1%
	Cultural Thicket	6,616	2%
	Total	131,120	40%
Urban/Extraction Land Use			
	Transportation	5,474	2%
	Extraction	2,325	0.7%
	Built-up Area Pervious	3,363	1%
	Built-up Area Impervious	26,005	8%
	Total	37,167	11%
Total Area		330,741	100%

[9] The Ecological Land Classification (ELC) map layer is the result of the LSRCA mapping program in to map the entire LSRCA jurisdiction of the watershed. (Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig and S. McMurray. 1998. *Ecological Land Classification for Southern Ontario: First Approximation and its Application*. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.)

[10] Treed swamp includes coniferous swamp, deciduous swamp and mixed swamp. This land cover type is also counted as wetland along with thicket swamp, however, the total natural cover and total area counts only the wetland area of swamps to avoid double-counting the total land area.

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.[11] In addition, water (e.g. lakes, rivers and streams) covers 72,141 hectares of the watershed.

Other land use was classified as built-up area, extraction area or transportation land use. Rural development, commercial, estate residential, industrial, institutional and urban land use were classified as built-up impervious cover (26,005 hectares). Golf courses and manicured open space were classified as built-up pervious cover (3,363 hectares). In addition, active and inactive aggregate extraction areas were classified as extraction land use, and rail and roads were classified as transportation land use.

The land cover and land use for the Lake Simcoe watershed are illustrated in Figure 3.

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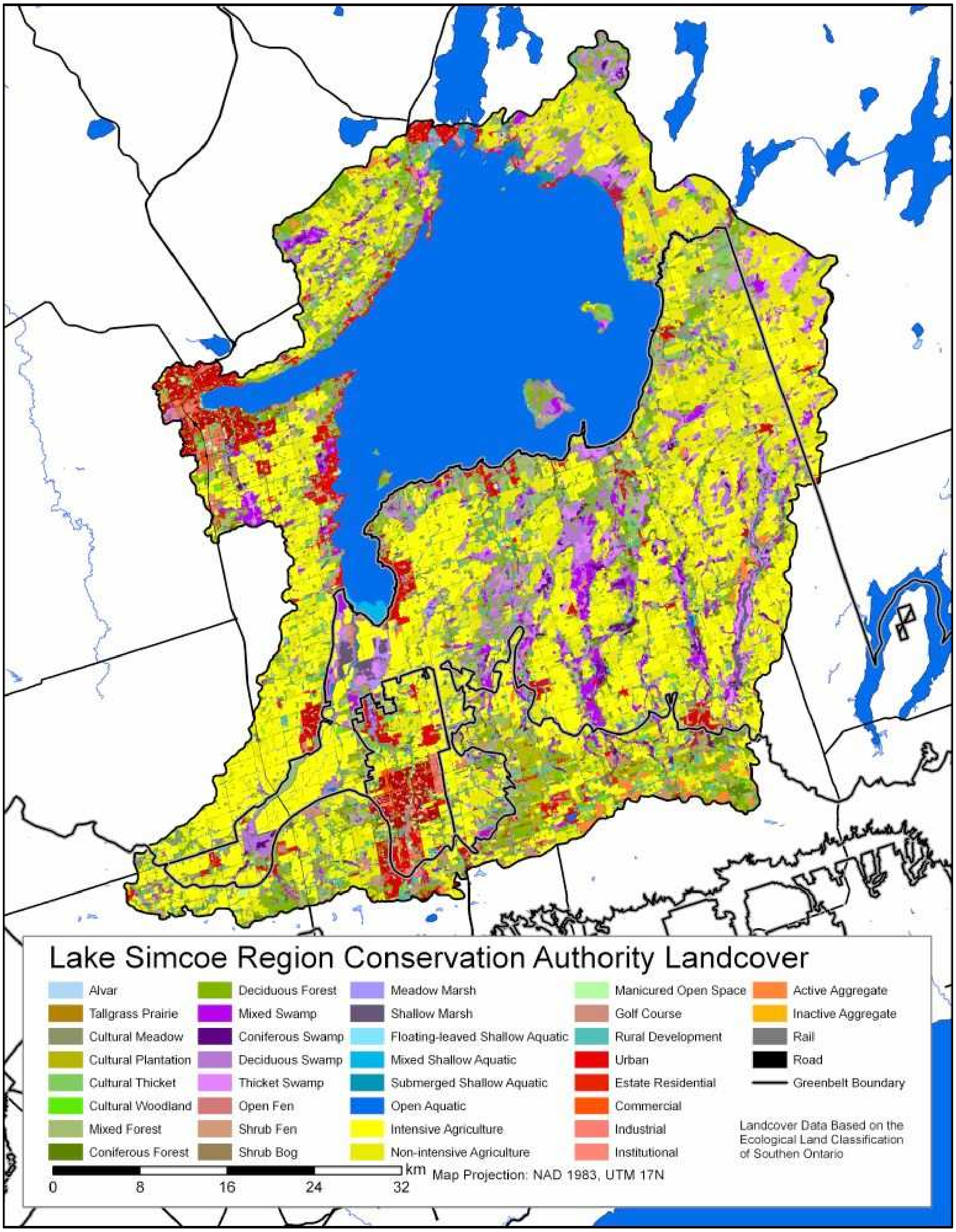
[11] The total natural cover area is less than the three cover types added total because treed swamp cover is counted and classified as both forest and wetland, but only counted once in total natural cover area.

Figure 4: Lake Simcoe Watershed Land Cover, Water Cover and Land Use (ELC)



5.0 Lake Simcoe Watershed's Ecosystem Values

With the understanding of the land and water cover in the basin, the next step is to estimate the worth of ecosystem services, using avoided cost and replacement cost analysis.

5.1 Water Quality, Supply & Regulation

Water pollution comes from point sources such as industrial discharges and wastewater treatment plants, and from non-point sources including runoff from agricultural lands and facilities, urban areas, construction sites, and failed septic tanks. Poor water quality degrades recreational areas and fish habitats, and affects human health by increasing insect and waterborne diseases. It also leads to odour problems and diminished scenic values.

Forests and wetlands can reduce non-point source water pollution because they filter, store, and absorb pollutants, such as nitrogen and phosphorus. Studies by the Environmental Protection Agency in the United States show that forests in rural areas improve water quality because trees divert rainwater into the soil where bacteria and micro organisms filter out pollutants.[12] This filtering significantly reduces the sediment, pollutants and organic matter that reach streams.

5.1.1 Water Filtration Services

Forested watersheds are vital for a clean and regular supply of drinking water. Protected forests provide higher quality water with less sediment and fewer pollutants than water from watersheds with unprotected forests.[13] A recent study concluded that the cost of treatment for surface water supplies varies depending on the per cent forest cover in the water source area.[14] In other words, where forest cover is low, water treatment costs more.

The forest/wetland cover in the Lake Simcoe watershed (80,182 ha) is 32 per cent of the total land cover (250,207 hectares). A U.S. study found that there is a 20 percent increase in water treatment costs for each 10 percent loss in forest cover.[15] The value of the forest/wetland cover for water filtration is calculated based on this statistical correlation and the potential increase in water treatment costs if the current forest/wetland cover declined from 30 per

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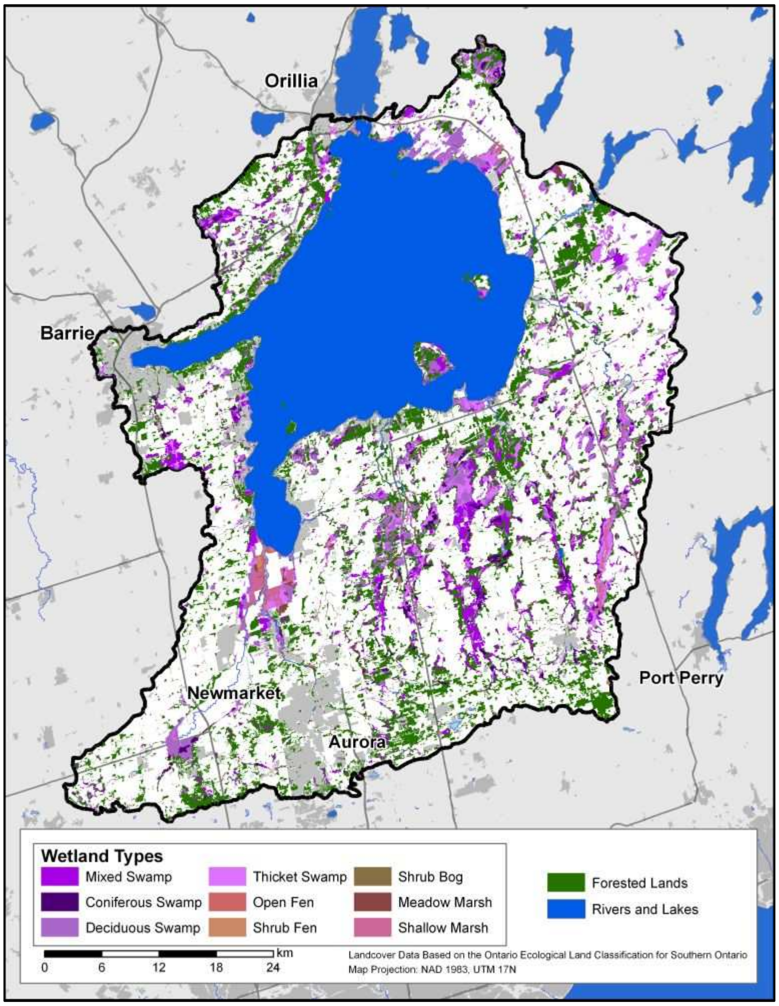
[12] Winogradoff, D.A. 2002. Bioretention Manual. Prince Georges County, MD. Department of Environmental Resources Programs and Planning Division. http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/Bioretention/pdf/intro_bioretention.pdf (accessed February 2008; cited by Nowak, D.J., Wang, J., and Endreny, T. 2007. "Environmental and Economic Benefits of Preserving Forests within Urban Areas: Air and Water Quality." In: *The Economic Benefits of Land Conservation*. The Trust for Public Land. San Francisco, California.)
[13] Dudley, N. and Stolton, S. 2003. *Running Pure: The importance of forest protected areas to drinking water*. World Bank/WWF Alliance for Forest Conservation and Sustainable Use. Washington DC.
[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] Ibid.

cent to 10 per cent.[16] The value of the current forest/wetland cover for water filtration services is $17.2 million, (i.e. the difference in annual costs) based on the estimated daily residential water use in the watershed (137,736 m^3).[17] The annual value per hectare is $209.86.

Figure 5: Forest and Wetland Cover in the Lake Simcoe Watershed



5.1.2 Water Sources

A safe and reliable source of water for communities is important, both now and in the future. The value of the watershed's water systems for drinking water is estimated based on the costs for providing residential drinking water (excluding the treatment costs that were used as a

[16] Methodology is adapted from: Wilson, S. *The Value of the Greenbelt's Ecosystem Services*. David Suzuki Foundation and the Greenbelt Foundation (to be released Sept. 2008). The cost for water treatment for drinking water by the City of Toronto is used as an estimate ($0.60 per cubic metre). Analysis shows that water treatment costs would increase to $0.94 per cubic metre if the natural cover in the watershed declined to 10 per cent of the watershed.

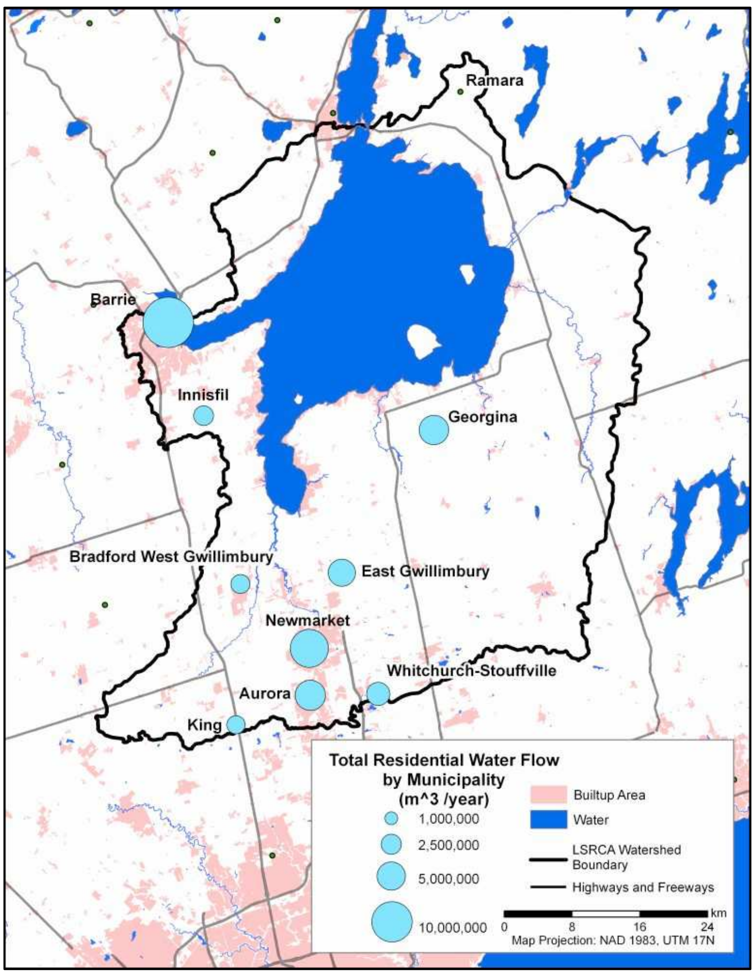
[17] The daily residential water use for the Lake Simcoe Watershed was calculated based on annual total water flow data extracted from Environment Canada's 2007 Municipal Water Use Report: Municipal Water Use, 2004 Statistics. http://www.ec.gc.ca/water/en/manage/use/e_data.htm (accessed June 2008).

proxy for water filtration services in 5.1.1). In other words, the cost reflects 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 of 137,736 cubic metres.[18] Given the 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.

It is useful for comparison to consider the total replacement cost for water. For example, if the daily residential water use in the Lake Simcoe watershed had to be replaced by bottled water, the daily cost would be $207 million (137.7 million litres at $1.50 per litre), or $75.4 billion per year.

Figure 6: Municipal Water Use in the Lake Simcoe Watershed



[18] 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 we 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.

5.1.3 Water Regulation and Flood Control

Forests and wetlands also regulate the flow of water providing protection against flooding and erosion. The loss of forest affects stream flows leading to instability in drainage systems, reduced infiltration of water into soils, and increased peak flows. Wetlands act as natural retention reservoirs for water, slowing the release of water. Changes in stream flow due to forest and wetland loss results in: (i) lower water levels in dry seasons; (ii) higher than normal water levels in wet seasons or storms; (iii) greater amounts of sediment entering rivers; and, (iv) increased water temperatures.[19]

The value of water regulation by forests is calculated as a replacement value using the CITYGreen software.[20] More specifically, the replacement value is the construction costs for water runoff control if the current forest cover was removed and converted for urban land use. The forest cover provides savings because it provides green infrastructure for the region. The total annual savings are $125.20 million or $1,886 per hectare.[21] For each five per cent of forest cover converted to urban land use, the incremental cost is an estimated $458 per hectare per year.

The annual value of flood control by wetlands is based on an average ($4,039 per hectare of wetland) derived from four different studies.[22] Based on this average, the annual value of the watershed wetlands for flood control is estimated at $157.4 million.

5.1.4 Waste Treatment

Wetlands are effective waste treatment systems. In fact, constructed wetlands are often used to treat human and agricultural wastes. They 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 amount that a wetland can absorb varies depending on the type, size, plants and soils. Estimates range from 80 to 770 kg/ha/year for phosphorus removal, and 350 to 32,000 kg/ha/year for nitrogen removal.[23] Using the low-end estimates for nutrient removal rates and the total wetland area, Lake Simcoe wetland cover has the estimated capacity to

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[19] Ribaudo, M.O. 1986. "Regional estimates of off-site damages from soil erosion." In: *The off-site costs of soil erosion*. (Ed.) T.E. Waddell. (Proceedings of a symposium held May 1985.)

[20] CITYgreen is a GIS application for land-use planning and policy-making. It conducts statistical analyses of ecosystem services, and calculates dollar benefits based on specific site conditions.
American Forests. CITYgreen software ArcGIS 8.x http://www.americanforests.org/productsandpubs/citygreen/

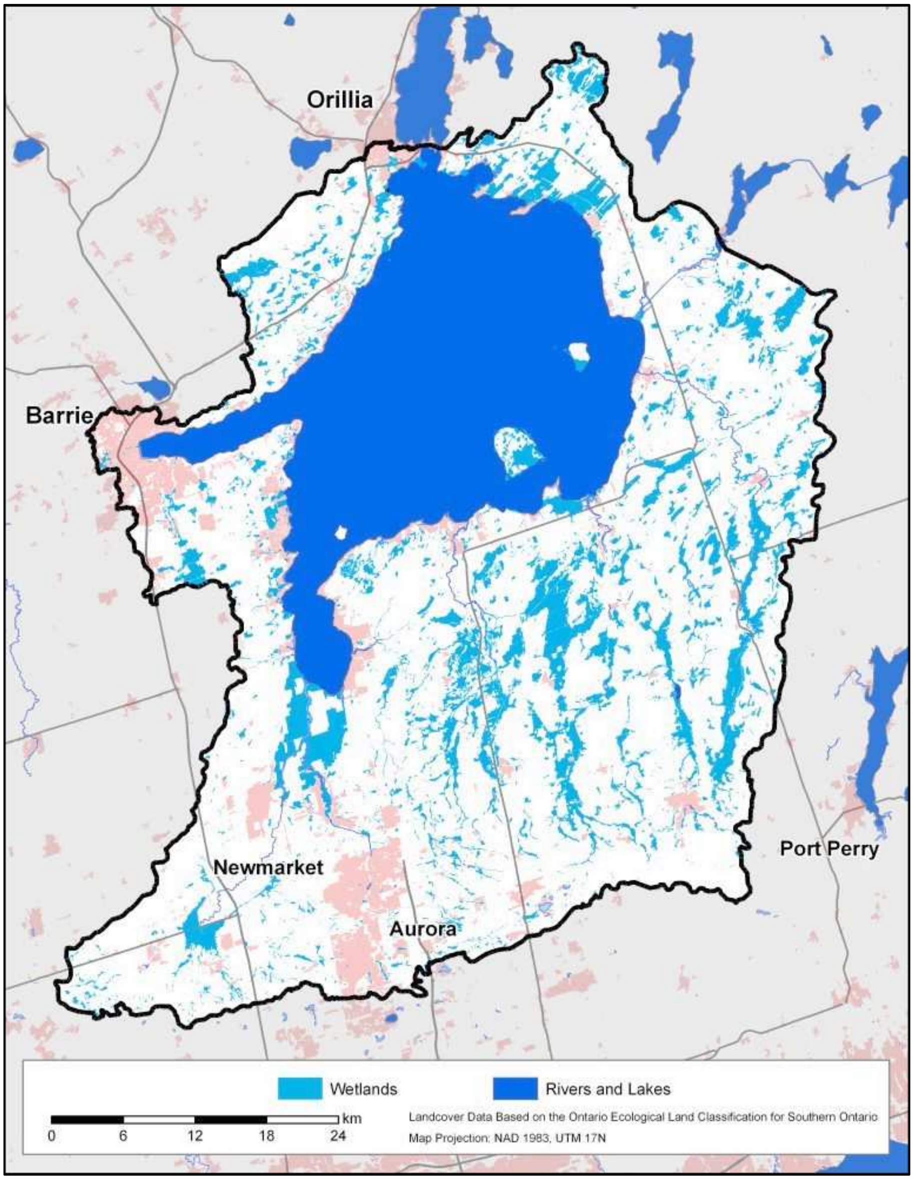
[21] Results are from analysis by CITYgreen software, using construction cost of $57 per cubic metre. Annualized savings are calculated over 20 years.

[22] A global average value of $12,502/ha from: Costanza, R. et al. 1997. "The value of the world's ecosystem services and natural capital." *Nature*. 387:253-259; 2) the average value of $1,341/ha for flood control by wetlands in the Seattle, Washington area reported by: Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited Canada and the Nature Conservancy of Canada.; 3) the average value of $1,538 from a global meta-analysis study; Woodward, R. and Wui,Y. 2001. "The Economic Value of Wetland Services: A Meta-Analysis," *Ecological Economics*. 37: 257-270. 4) The average value from a World Wildlife Fund global wetland study ($773) per hectare per year from: WWF. 2004. *Living Waters: Conserving the source of life. The Economic Values of the Worlds' Wetlands*. World Wildlife Fund and the Swiss Agency for the Environment, Forests and Landscape. Gland, Amsterdam.
http://panda.org/downloads/freshwater/wetlandsbrochurefinal.pdf.

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

remove 3.1 million kilograms of phosphorus and 13.6 million kilograms of nitrogen each year.[24]

Figure 7: Wetland Cover in the Lake Simcoe Watershed



Nitrogen loss from Lake Simcoe croplands is an estimated 1.14 to 2.28 million kilograms per year, based on the annual loss of nitrogen that poses a risk for water contamination (10 to 20 kg N/ha) as reported by Agriculture and Agri-Food Canada (AAFC) for the majority of

[24] 38,974 hectares of wetlands in the Lake Simcoe watershed multiplied by the low-end estimates of removal rates of 80.3 kg/ha/year of phosphorus and 350 kg/ha/yr of nitrogen.

Ontario's farmlands (73%).[25] 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. 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. Using the average cost as a proxy for the value of wetland waste treatment services for excess nitrogen, the annual value is an estimated $407 per hectare (i.e. range from $94 to $526/ha/year).

Information on the risk of water contamination by phosphorus is not available for Ontario. However, the national average for excess phosphorus is 14.3 kilograms per hectare per year. Applying this national average to the hectarage of cropland in the Lake Simcoe watershed, an estimated 1.7 million kilograms of excess phosphorus may run off croplands in the watershed. Based on a low-end estimate (80 kg/ha/year), the watershed wetlands have the capacity to absorb at least 3.1 million kilograms of phosphorus per year. The value of wetland treatment services for excess phosphorus is $1,838 per hectare per year (average value with a range of $967 to $2,709/ha/year), based on the costs of water treatment to remove excess phosphorus.[26]

Thus, the combined annual total for waste treatment of nitrogen and phosphorus by wetlands in the Lake Simcoe watershed is an estimated $83.7 million or $2,148 per hectare (based on a range of values from $1,061 to $3,235/ha/year).

5.2 Clean Air

Trees are essential because they produce oxygen for our air. On average, one tree produces nearly 260 pounds of oxygen each year, meaning that two trees can provide enough oxygen for a family of four.[27] Forests and trees also provide improvements in air quality. Trees remove gaseous air pollution such as carbon monoxide and sulfur dioxide by absorption through their leaves and they also intercept airborne particles by retaining them on their leaves. For example, studies show that trees can remove 8 to 12 grams of air pollutants per square metre of canopy.[28]

Air pollution increases human health and environmental costs. A recent study calculated that air pollution costs Ontario approximately $10 billion each year due to health and

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[25] 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).

[26] Low-end estimate is $21.85/kg. High-end estimate is $61.20/kg. Reported by: Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited Canada and the Nature Conservancy of Canada.

[27] Environment Canada. 2005. Envirozine. Issue 58. http://www.ec.gc.ca/envirozine/english/issues/58/any_questions_e.cfm

[28] Nowak, D.J., Wang, J., and Endreny, T. 2007. "Environmental and Economic Benefits of Preserving Forests within Urban Areas: Air and Water Quality." In: *The Economic Benefits of Land Conservation*. The Trust for Public Land. San Francisco, California. http://www.tpl.org/tier2_rp1.cfm?folder_id=175 (accessed Nov. 5, 2007)

environmental damages in southern and central Ontario.[29] 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 Lake Simcoe watershed, 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.[30]

CITYgreen software was used to assess the amount of air pollutants removed by the tree canopy cover in the watershed.[31] 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.[32] The results show that the watershed's tree cover (66,378 ha) removes almost 4 million kilograms of pollutants per year (60 kilograms of pollutants per hectare). The kilograms removed per hectare range from 1.2 kg/hectare for carbon monoxide to 30.3 kg/hectare for ozone (Table 3). The annual value of this service is $25 million per year; $377 per hectare.

Table 3: The Value of Air Pollutants Removed by Tree Cover

Annual Air Pollution Removed				
	Kilograms per hectare	**Value per kilogram**	**Value per hectare**	**Total Value ($ per year)**
Carbon monoxide	1.2	$1.04	$1.25	$83,112
Ozone	30.3	$7.51	$227.59	$15,107,561
Nitrogen Dioxide	7.5	$7.51	$56.34	$3,739,495
Particulate Matter	16.8	$5.01	$84.25	$5,592,565
Sulfur Dioxide	4.2	$1.83	$7.71	$511,538
Totals	60.0	$6.29	$377.14	$25,034,271

Note: Treed swamp area is included as forest cover

5.3 Carbon Services

Globally, forests and wetlands function as large terrestrial banks of carbon, preventing increases in the level of greenhouse gases in the atmosphere. Forests and wetlands play an integral role in the global carbon cycle by pulling carbon with the atmosphere. As a result, large amounts of carbon are stored in trees, plants, roots, and soils.

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[29] 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)

[30] Ibid.

[31] American Forests, CITYgreen software ArcGIS 8.x http://www.americanforests.org/productsandpubs/citygreen/

[32] 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.

5.3.1 Forests

Carbon storage and annual carbon sequestration by forests are often misunderstood. Forest carbon storage refers to the total amount of carbon contained in an ecosystem at a given time. Carbon sequestration, on the other hand, refers to the annual amount of carbon uptake by an ecosystem after subtracting the carbon released to the atmosphere due to respiration, disturbance and decomposition.

For the purposes of this calculation, 'forest' includes both upland forest and wooded wetlands (swamps) as the calculation relates to the amount of wooded cover on the landscape (total of 66,379 ha). Lake Simcoe's forests are part of the Cool Temperate (CT) eco-climatic zone, storing on average 220 tonnes of carbon per hectare.[33] Based on this average, the total carbon stored is an estimated 14.6 million tonnes of carbon, or 53.5 million tonnes CO_2e (carbon dioxide equivalent).[34] The carbon stored is the equivalent of carbon emissions due to energy use by 4.7 million households over one year, or 9.8 million cars driven over one year.[35]

The economic value of the carbon stored by forests can be calculated using the avoided cost (i.e. damages avoided), replacement cost, or the market price of carbon trading. Here, the avoided cost is used because it reflects the actual damages avoided by the carbon stored. The IPCC (Intergovernmental Panel on Climate Change) reported the average cost of global damages due to the level of carbon dioxide in the atmosphere in 2005 was $52 per tonne of carbon.[36] Therefore, the annual value of the carbon stored was worth an estimated $61 million ($919 per hectare) in 2005 (C$2005).[37].

The annual uptake of carbon (i.e. net carbon sequestration) was calculated using CITYgreen software.[38] Based on the total tree canopy cover area, the carbon annually sequestered is approximately 49,859 tonnes of carbon, or an annual average of 0.75 tonnes of carbon per hectare. The annual value is $2.6 million per year or $39 per hectare based on the average cost of carbon emissions (C$52/tC).[39]

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

[34] S. Wilson's calculations using the area for forest lands in the Lake Simcoe watershed derived by spatial land cover analysis of the ELC land cover and carbon content estimates for the Cool Temperate eco-climatic province from: Kurz, and Apps 1999. "A 70-Year Retrospective of Carbon Fluxes in the Canadian Forest Sector." *Ecological Applications*. 9: 526- 547.

[35] Calculated using The US EPA Greenhouse Gas Equivalencies Calculator; http://www.epa.gov/cleanenergy/energy-resources/calculator.html (4.62 metric tons CO_2E /passenger car/year); Source: EPA (2003). *U.S. Inventory of Greenhouse Gas Emissions and Sinks 1990-2001*. Office of Atmospheric Programs, U.S. Environmental Protection Agency, Washington, DC. EPA 430-R-03-004.

[36] 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..

[37] 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). In order to assess the annual value, the carbon stored by forests was considered as an annuity investment over 20 years. Adapted from Anielski and Wilson (2007), a 20-year annuity was used because of the urgent timeline for carbon management for climate change, and because of the risks 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.

[38] American Forests. CITYgreen software ArcGIS 8.x http://www.americanforests.org/productsandpubs/citygreen/

[39] See footnote #38.

5.3.2 *Wetlands*

Carbon storage by wetlands was determined using Canada's Soil Organic Carbon Database.[40] Using data extracted from this database, 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 value per hectare ranges from $524 to $1,302 per year depending on the type of wetland (i.e. shallow water, bog, marsh, swamp and fen), and the soil carbon ranges from 125 to 312 tonnes per hectare.[41]

Table 4: Wetland Soil Carbon Stored by Wetland Type

Wetland type	Area (ha)	Soil Organic Carbon (tonnes)	Soil Organic Carbon (tonnes/ha)
Swamp	31,791	3,985,585	125
Marsh	4,925	841,229	171
Shallow Water	1,778	265,188	149
Fen	455	141,726	312
Bog	25	5,771	232
Total wetland cover	38,974	5,239,499	134

The annual carbon sequestered is calculated based on the global average of sequestration rates for wetlands. These annual rates range from 0.2 to 0.3 tonnes of carbon per hectare. Using the average rate (0.25 tonnes per hectare per year),[42] the annual rate of carbon uptake is 9.743 tonnes, worth $13 per hectare ($507,370 per year).

This is most likely a very conservative estimate because other studies have found higher rates of carbon uptake.[43]

5.3.3 *Agricultural Land and Grasslands*

Organic carbon stored in the agricultural soils of the Lake Simcoe watershed was extracted from the Canadian Soil Organic Carbon Database.[44] Results show that agricultural soils store 16 million tonnes of carbon. The carbon stored is worth $66.8 million per year based on the

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[40] 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.

[41] 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). In order to assess the annual value, the carbon stored by wetlands was considered as an annuity investment over 20 years. Adapted from Anielski and Wilson (2007), a 20-year annuity was used because of the urgent timeline for carbon management for climate change, and because of the risks 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.

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

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

[44] 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.

average cost of carbon emissions; an average annual value of $547 per hectare (C$52/tC).[45] 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.

Grasslands in the watershed store a total of 836,306 tonnes of carbon, an average of 100 tonnes per hectare (includes cultural meadow, alvar meadow, and tallgrass prairie land cover). The annualized value of carbon stored in grassland is worth an estimated $3.5 million per year, or $438 per hectare per year, over 20 years.[46]

In terms of carbon sequestration, land in permanent cover sequesters more carbon than tilled land because of lower decomposition rates and a higher input of plant residue back into the soil.[47] Although the rate of sequestration depends on the type of cover, the change from conventional crop tillage to permanent cover is estimated to increase sequestered carbon by 1.8 tonnes of carbon dioxide (0.5 tC) per hectare per year compared with conventional crop cover.[48] Based on this information, we estimated the value of idle land, orchards, and hedgerows to be $28.46 per hectare.

5.4 Biodiversity

5.4.1 Habitat

Wetlands are well known for the important habitat they provide for many species, especially birds, amphibians and reptiles. The Lake Simcoe watershed is home to at least 32 of the 175 species at risk in southern Ontario.[49]

The annual value for wetlands habitat services is $247 million or $5,830 per hectare based on the average annualized wetland habitat restoration costs for a group of relevant Great Lakes Sustainability Fund projects.[50] Projects include the Rouge Watershed Wetland Creation Project, Humber Bay Shores Butterfly Meadow, and the Granger Greenway Habitat Enhancement project.[51] The annualized value of restoring habitat represents the value of wetland habitat in terms of the avoided cost of damages to habitat. This is important in southern Ontario, in general, where approximately 70 per cent of wetlands have been drained for other land use such as agriculture and urban development.[52]

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[45] 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.
[46] Ibid.
[47] 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..
[48] 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.)
[49] Lake Simcoe Region Conservation Authority (LSRCA). http://www.lsrca.on.ca/speciesatrisk/index.html
[50] 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)
[51] Ibid.
[52] Natural Resources Canada, *Wetlands, The Atlas of Canada,* http://atlas.nrcan.gc.ca/sie/english/learningresources/theme_modules/wetlands/index.html

The avoided cost of the loss or degradation of wetland habitat is also significant because of the importance of wetlands for many species, especially species at risk. For example, Canada's wetlands are essential to the survival of migratory bird populations in the Western Hemisphere and polar regions. In Canada, more than 200 bird species (including 45 species of waterfowl) and over 50 species of mammals depend on wetlands for food and habitat, many of these are species at risk. One third of the species at risk listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) live in or near wetlands.[53]

5.4.2 Pollination

Pollination is the transfer of pollen from one flower to another, which is critical for fruit and seed production in most plants. Approximately 80 per cent of all flowering plant species are specialized for pollination by animals, mostly insects. Without this service, many interconnected species and ecosystem functioning within an ecosystem would collapse.[54] Insect pollination is necessary for most fruits and vegetables including annual crops such as tomatoes, peppers and strawberries, as well as tree fruits such as apples and peaches. About 30 per cent of the world's food production is from crops that depend on pollinators like bees, insects, bats, and birds.[55]

Several studies have documented the significance of the proximity of natural habitat to cropland for optimum yields and increased farm production. A Canadian study concluded that canola yield is correlated to the proximity of uncultivated areas. The researchers found that optimum yield and profit would be attained if 30 per cent of the field areas were set aside for wild pollinator habitat.[56] Similarly, studies that examined pollination and surrounding land use for tomato and sunflower production found that natural habitat near farms increases pollination services.[57]

Based on the importance of natural cover and habitat for both honeybee and wild pollination services, we analyzed the proximity of cropland to natural cover in the Lake Simcoe watershed was analyzed: 91 per cent of the agricultural lands have 20 to 40 per cent natural cover within a two kilometre radius.

The annual value of pollination services for the watershed is an estimated $98 million based on 30 per cent of farm crop value (global average of crop production dependent on pollination). This proxy value was calculated by multiplying the total value of farm crops in

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[53] Ibid.

[54] Commission on Genetic Resources for Food and Agriculture. Pollinators: Neglected Biodiversity of Importance to Food and Agriculture. Food and Agriculture Organization of the United Nations (FAO). Rome (June 11-15, 2007). ftp://ftp.fao.org/ag/cgrfa/cgrfa11/r11i15e.pdf (accessed February 2008)

[55] Klein,A.-M., et al. 2007. "Importance of pollinators in changing landscapes for world crops." *Proceedings of the Royal Society B*. 274:303-313.

[56] Morandin, L.A. and Winston, M.L. 2006. "Pollinators provide economic incentive to preserve natural land in agro-ecosystems." *Agriculture, Ecosystems and Environment*. 116:289-292.

[57] 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.

the Lake Simcoe watershed ($326.6 million in 2005) by 30 per cent. Given the significance of natural cover for pollinator biodiversity, nesting habitat, food, and nectar, the total value of pollination services was allocated proportionally to idle agricultural lands, grazing lands (perennial croplands), hedgerows/cultural woodland, forest lands, and grasslands with an average annual value per hectare of $951 (Table 5).

Table 5: The Value of Pollination Services by Natural Cover Type

Natural Cover	Area (hectares)	Percent of natural cover area	Pollination services ($/ha)	Total value $millions
Hedgerow/Cultural Woodland	3,855	4%	$951.05	$3.7
Total forest	66,379	64%	$951.05	$63.1
Total grassland	8,353	8.1%	$951.05	$7.9
Grazing lands (pasture)	24,447	23.7%	$951.05	$23.2
Total natural cover	103,033	100%	$951.05	$98.0

5.5 Recreation/Tourism

The most important industries associated with Lake Simcoe is tourism and recreation.[58] Approximately $200 million is spent annually on tourism and recreation in the watershed. Three provincial parks, including Sibbald Point have an annual visitation of over 300,000 people. Fishing attracts 144,000 anglers each year, who spend about 746,000 hours annually on these activities. Ice fishing is extremely popular in the region. Each year there are between 2,000 to 4,000 ice huts on Lake Simcoe. In addition, there are over 12,000 cottages on the lake, which adds 50,000 people to the region during the summer.

All of these activities depend largely on the health of the watershed and the lake. The total natural cover (forests/wetland/grassland) and water cover in the watershed is 162,454 hectares. Based on the annual value of tourism, this area is worth $1,231 per hectare in terms of recreation and tourism activities. This value assumes that without natural areas and the lake, tourism and recreation would not be viable in the region.

5.6 Other Ecosystem Services

Additional valuations of ecosystem services provided by the watershed are listed below.

Air quality

- Mitigation of air pollution by grasslands is an estimated $12 per hectare per year based on an average global value[59]

[58] Recreation, Lake Simcoe Environmental Management Strategy, www.lsems.info/lakesimcoe/recreation.html
[59] Ecosystem benefits or values are from: Costanza, R. et al. 1997. "The value of the world's ecosystem services and natural capital."

- Mitigation of air pollution by urban recreational areas (i.e. built-up pervious land cover) is estimated to occur at 50 per cent the service provided by natural cover ($188.57 per hectare per year). See CITYgreen analysis results in Section 4.2

Water regulation

- Water regulation services by grasslands are worth an estimated $7 per hectare per year based on a average regional value[60]
- Water regulation on pervious urban recreational areas is worth an estimated $19.88 per hectare per year[61]

Erosion Control

- Erosion control and sediment retention by grasslands are valued at $50 per hectare per year based on an average global value[62]
- Erosion control and sediment retention by pasture lands, hedgerows and cultural woodlands (i.e. agricultural land) is worth an estimated $5.60 per hectare per year[63]

Soil Formation

- Soil formation by grasslands is a service worth $10 per hectare per year based on a regional average value[64]
- soil formation by forests is a service worth $17 per hectare per year based on an average global value[65]
- Soil formation based on the soil building by earthworms for cropland, pasture, and hedgerow/cultural woodland is worth an estimated $6.06 per hectare per year[66]

Seed Dispersal

- Seed dispersal (i.e. natural regeneration of trees) is worth $537 per hectare per year[67]

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[60] Ecosystem benefits or values are from: Costanza, R., et al. 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.

[61] Constanza, R. et al. 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.

[62] Ecosystem benefits or values are from: Costanza, R. et al. 1997. "The Value of the world's ecosystem services and natural capital.

[63] Canadian Urban Institute. 2006. *Nature Counts: Valuing Southern Ontario's Natural Heritage*. Toronto, Canada (Prepared for the Natural Spaces Leadership Alliance/Ministry of Natural Resources) http://www.canurb.com/media/pdf/Nature_Counts_rschpaper_FINAL.pdf

[64] Ecosystem benefits of values are from: Costanza, R., et al. 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.

[65] Ecosystem benefits or values are from: Costanza, R. et al. 1997. "The Value of the world's ecosystem services and natural capital."

[66] Sandhu, H.S., et al. 2008. "The future of farming: The value of ecosystem services in conventional and organic arable land. An experimental approach." *Ecological Economics*. 64: 835-848.

[67] Ecosystem benefits or values from: Constanza, R. et al. 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. (Value originates from: Hougner, C., Colding, J., and Soderzvist, T. 2006. "Economic valuation of a seed dispersal service in the Stockhold National Park, Sweden." *Ecological Economics*. 59: 364-374.)

Nutrient Cycling

- Nutrient cycling by pasture land and hedgerow/cultural woodland soils is worth an estimated $23.50 per hectare per year[68]

Recreation

- Recreational values for pervious urban recreational areas are estimated at 50 per cent of the value for natural cover ($615.56 per hectare per year). See Recreation section above.

[68] Canadian Urban Institute. 2006. *Nature Counts: Valuing Southern Ontario's Natural Heritage*. Toronto, Canada (Prepared for the Natural Spaces Leadership Alliance/Ministry of Natural Resources) http://www.canurb.com/media/pdf/Nature_Counts_rscpaper_Final.pdf)

6.0 Summary of Lake Simcoe Watershed Ecosystem Services

The total annual value of the watershed's non-market ecosystem services is an estimated $975 million, or an average of $2,948 per hectare per year (see Appendix C for a detailed breakdown).

The ecosystem services attributed with the highest value per hectare are habitat, flood control, recreation, waste treatment, climate regulation, and pollination (see Table 6 below).

Table 6: Summary of Watershed's Ecosystem Service Values by Ecosystem Service

Ecosystem Service	Total Value ($/ha/year)
Air quality	$954.94
Climate regulation (stored)	$8,117.47
Climate regulation (annual sequestration)	$257.16
Flood control (wetlands)	$20,192.55
Water regulation (control of runoff – forests)	$943.60
Water filtration and supply network	$2,650.32
Erosion control and sediment retention	$66.88
Soil formation	$62.64
Nutrient cycling	$70.50
Waste treatment	$10,858.73
Pollination (agriculture)	$4,755.24
Habitat/Refugia	$29,154.42
Recreation and aesthetics	$11,820.62
Total per hectare ($/ha/year)	$2,948.42 ($/ha/year)
Total area (ha)	330,741 (ha)
Total value (millions$/year)	$975.16 (millions$/year)

By land cover type, the highest values per hectare are attributed to wetlands and forests (see Table 7 below). 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. 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.

Forests provide high value because of their importance for water filtration services, carbon storage services, habitat for pollinators, wildlife and recreation. They provide key services worth $319 million each year.

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 7: Summary of Non-Market Ecosystem Service Values <u>by Land Cover Type</u>

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

7.0 Conclusions

Residents living in and around Lake Simcoe, as well as visitors to the area, benefit from the goods and services that the lake and its watershed provides --- water supply and filtration, flood control by wetlands, climate regulation resulting from carbon storage, and recreational benefits. These so-called “free” ecosystem services have, in fact, significant value. The analysis in this report provides a first approximation of the value of watershed non-market ecosystem services – at least $975 million annually. Put another way, every one of the 350,000 residents receives $2,780 annually in ecosystem services. Just as importantly, they are saved the expense of replacing these services if the integrity and functioning of the watershed is diminished.

It is critical that the true value and the costs of potentially damaging these ecosystem services be taken more directly into account in municipal and provincial government, and business decision-making. We also have the opportunity to build on existing ecosystem services by enhancing the natural capital of the watershed through restoration of woodlands, wetlands and other forms of natural cover as well as through stewardship activities.

The ecosystem values presented in this report 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. It is important to note that ecosystem values should not be relied on solely, but considered in conjunction with other sources of information, such as biophysical and non-monetary ecological information.

Measuring the value of, and monitoring, natural capital and the ecosystem services that it provides will become even more important as the climate changes. The Intergovernmental Panel on Climate Change’s (IPCC) latest report states that human pressures on natural ecosystems need to be reduced in order for our ecological systems to cope with the changing climate.[69] Landscape scale protection of land and ecosystems will provide the additional benefit of our greater ability to cope and adapt in the face of climate change.

[69] 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.

8.0 Recommendations

The residents and communities in and around Lake Simcoe Watershed depend on its ecosystems for clean water and air, safe and abundant food and other economic, social and ecological benefits. The scope and condition of a watershed's natural capital directly affects the ability of its connected ecosystems to function and provide these benefits. In order to maintain, and restore where necessary, the ecosystem's natural capital, the following recommendations are made:

1. 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 natural heritage features, including through implementation of a natural heritage system common to the entire watershed.

2. 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.

3. The provincial government, associated municipal governments, and the Conservation Authority should examine creating an integrated natural capital account system for the Lake Simcoe watershed. Such accounts would 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.

Appendix A

Ecological Land Classification (ELC) Methodology

1.0 Introduction

The Ecological Land Classification (ELC) (Lee *et al*. 1998) map layer is the primary building block of the Lake Simcoe Watershed Natural Heritage System. This data layer is more accurately described as the Natural Heritage and Land Use Map as it consists of two principal land classification data components: natural heritage and land use. The LSRCA initiated the mapping program in 2000 to map the entire LSRCA jurisdiction of the Lake Simcoe Watershed in order to achieve a mapping product with complete coverage.

2.0 Methodology

A grid was created for each sub-watershed and hard copy sheets of aerial photographs were printed. Additional layers such as evaluated wetlands (from the Ministry of Natural Resources), 5 m contours, watercourses, and Areas of Natural and Scientific Interest (ANSIs) were superimposed onto the digital photographic base. The landscape was then delineated on the hard-copy sheets using on-screen information for assistance. In addition to the layers on the hard-copy sheets, other sources of information included: soils, parcel fabric, and watershed boundaries. The minimum polygon size for a natural heritage feature was generally 0.5 ha, however some smaller units (generally wetlands) were included where it was thought to be appropriate.

Natural Heritage
Each natural heritage feature identified was assigned a unique code, specific to that watershed. Each code referred to a unique natural heritage record, comprised of an ELC code to Community Series (i.e., deciduous forest, mixed swamp, cultural meadow, etc.), which also included the other standard ELC community information: System (terrestrial, wetland, aquatic); Site (open water, surface deposits, etc.); Substrate (organic, mineral); Topography (rolling upland, tableland, bottomland, etc.); History (cultural, natural); Cover (treed, shrub, open); Form (submerged, deciduous, mixed, etc.); and Community (swamp, fen, forest, etc.).

Land Use
Land use was identified concurrently with the delineation and identification of the natural heritage features. The land use codes were based on the codes used by Credit Valley Conservation in its mapping. Land uses include: intensive agriculture (i.e., row crop, sod farm, etc.); non-intensive agriculture (hay, pasture); urban; rural development; estate residential; manicured open space; institutional; rail; and roads.

Mapping
Upon completion of hard copy delineation of polygons, sheets were heads-up digitized at a scale of 1:4000 using ArcView 3.2 (and more recently ArcGIS 9.1). Following the digitization of the polygons, points were added to each polygon that contained the natural heritage record code. The mapping was then processed such that each polygon contained a unique code. The mapping was then linked to the Access database containing the detailed record information. The resulting data layer enables the user to click on any polygon and read the information for that polygon. Recently the system has been revamped to eliminate the need for the Access database and contain all attribute information within ArcGIS.

Timing and Photographic Resources
The mapping was generally undertaken on a subwatershed basis, commencing with the 1999 colour orthophotography. The Region of York and the Township of Innisfil were originally mapped using 1999 50 cm colour orthogonally rectified aerial photography (orthophotography). The original mapping for the Region of Durham was done using 2000 20 cm black and white photography. The City of Barrie was mapped using 2001 10 cm black and white orthophotography. Oro-Medonte, Orillia and Ramara were mapped using 2002 20 cm colour orthophotography. York, Durham, Innisfil and Barrie were updated using 2002 20 cm colour orthophotography. Updates are on going as new orthophotos are received to identify changes in the landscape.

Staff
Three GIS staff were involved in the mapping process led by Darren Campbell, GIS Coordinator. There were four natural heritage interpreters involved in the mapping procedure led by Kim Baker, Senior Natural Heritage Biologist.

3.0 Other Information

Wetlands
The mapping contains three categories of wetlands: Ministry of Natural Resources (MNR) evaluated wetlands (Natural Resources and Values Information System - NRVIS), Oak Ridges Moraine wetlands (NRVIS), and interpreted wetlands. The MNR evaluated wetlands were integrated into the mapping as “Evaluated Wetlands”, as they existed in NRVIS; no edits were made to these polygons, except where obvious change had occurred (e.g., residential development). The ELC mapping is updated on an on-going basis to reflect recent MNR wetland evaluation updates. The wetland community information contained within the wetland evaluations was used to assist in applying the ELC protocol.

The Oak Ridges Moraine wetlands (those that were not evaluated wetlands) were originally identified and mapped by the MNR. These wetlands are included in the mapping as mapped by the MNR as “ORM wetlands” where they are greater than 0.4 ha.

The third category of wetland was "Interpreted". These were wetland units that were identified through interpretation of aerial photography and/or field checking. These wetlands may include areas adjacent to evaluated wetlands that had been missed during the evaluation, or may be in areas that have not been evaluated at the time of the ELC mapping.

Breaks in Polygons
Polygons generally begin and end based on either a change in vegetation community (e.g., FOD to FOC) or a change in topography (e.g., tableland to valleyslope). Anthropogenic features such as hydro transmission lines and pipelines were mapped according to their vegetative characteristics within ELC; usually as cultural meadow or cultural thicket. These linear features are therefore often visible in the vegetation mapping as a result of the linear vegetation community and do therefore represent breaks in other features such as forest. This approach, while conservative is also ecologically defensible. In general, all municipal road rights-of-way constitute a break in the vegetation. Roads were also delineated as polygons. Unopened road allowances were not mapped out as roads, but were strictly mapped based on their ELC vegetation communities.

Single family dwellings and their associated manicured areas, including driveways, were identified as rural development or estate residential, depending on the size and setting of the lot. Built up areas such as towns and cities were identified as urban. Trails were generally included within the vegetation community, unless they represented a change in vegetation community. Railways were delineated as "Railway" as a land use. Old railway lines that have been converted to trails are identified as "Manicured Open Space" (this category was also used for parks). Watercourses that were digitizable at 1:4,000 for a reasonable length were identified as "Open Water" and were delineated from the adjacent vegetation communities.

Other Features
Known Christmas tree farms and orchards were mapped as "Intensive Agriculture". All hedgerows that were continuous with another natural heritage feature were mapped as Cultural Woodlands (CUW) and noted as 'Hedgerow' in the attribute table. Isolated hedgerows (i.e., those not connected to another feature) were generally not mapped. However, some isolated hedgerows that were deemed to be 'substantial' (i.e., several trees wide or were dominant on the landscape) may have been mapped. All mapped hedgerows are identifiable in the attribute table.

Field Checking
Field checking was undertaken intermittently throughout the watershed, mostly by roadside reconnaissance by the Senior Natural Heritage Biologist, Natural Heritage Ecologist and Natural Heritage Technician. In addition, a blind field test of ELC data was undertaken as part of the NHS development.

ELC Codes

The following table provides the ELC codes used in this document.

ELC Community Code	ELC Community
AL	Alvar
BOO	Open bog
BOS	Shrub bog
CUM	Cultural meadow
CUP	Cultural plantation
CUT	Cultural thicket
CUW	Cultural woodland
FEO	Open fen
FES	Shrub fen
FOC	Coniferous forest
FOD	Deciduous forest
FOM	Mixed forest
MAM	Meadow marsh
MAS	Shallow marsh
OAO	Open aquatic
SAF	Floating-leaved shallow aquatic
SAM	Mixed shallow aquatic
SAS	Submerged shallow aquatic
SWC	Coniferous swamp
SWD	Deciduous swamp
SWM	Mixed swamp
SWT	Swamp thicket
TP	Tall grass prairie

4.0 Cited Literature

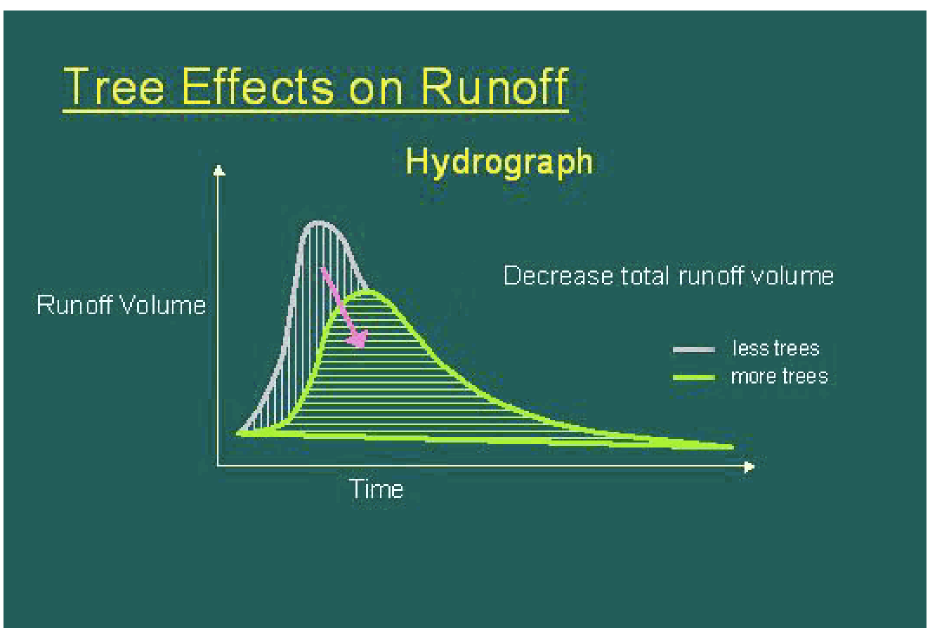
Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig and S. McMurray. 1998. Ecological Land Classification for Southern Ontario: First Approximation and its Application. Ontario Ministry of Natural Resources, South central Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.

Appendix B

CITYgreen Methods

Stormwater/Runoff Savings
Trees decrease total stormwater volume helping cities to manage their stormwater and decrease detention costs. CITYgreen assesses how land cover, soil type, and precipitation affect stormwater runoff volume. It calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained by stormwater facilities if the trees were removed. This volume multiplied by local construction costs calculate the dollars saved by the tree canopy. CITYgreen uses the TR-55 model developed by the US Natural Resource Conservation Service (NRCS), which is very effective in evaluating the effects of land cover/land use changes and conservation practices on stormwater runoff. The TR-55 calculations are based on curve number which is an index developed by the NRCS, to represent the potential for storm water runoff within a drainage area. Curve numbers range from 30 to 100. The higher the curve number the more runoff will occur. CITYgreen determines a curve number for the existing landcover conditions and generates a curve number for the conditions if the trees are removed and replaced with the user-defined replacement landcover specified in the CITYgreen Preferences. The change in curve number reflects the increase in the volume of stormwater runoff.

Water Quantity (Runoff)
Curve Number using default replacement landcover: 74
Curve Number reflecting existing conditions: 77
2-yr, 24-hr Rainfall: 51.60 mm
Construction cost per cubic meter: $57.00
Additional Storage volume needed: 17,353,483 cu. meters



Air Pollution Removal
By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10) in their leaves, urban trees perform a vital air cleaning service that directly affects the well being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for the pollutants listed below. To calculate the dollar value of these pollutants, economists use "externality" costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue. The actual externality costs used in CITYgreen are reported by the United States Public Services Commission. An average of each state in the US is used and the dollar value conversion is $1US = $1.11CAN (Nearest Air Quality Reference City: Oakville, Ontario).

The Air Pollution Removal program is based on research conducted by David Nowak, Ph.D., of the USDA Forest Service. Dr. Nowak developed a methodology to assess the air pollution removal capacity of urban forests with respect to pollutants such as nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10). Pollution removal is reported on an annual basis in pounds and U.S. dollars.

Dr. Nowak estimated removal rates for 10 cities: Atlanta, Georgia; Austin, Texas; Baltimore, Maryland; Boston, Massachusetts; Denver, Colorado; Milwaukee, Wisconsin; New York, New York; Philadelphia, Pennsylvania; St. Louis, Missouri; and Seattle, Washington. Average results from all 10 cities were used in our analysis. The program estimates the amount of pollution being deposited within a certain given study site based on pollution data from the nearest city then estimates the removal rate based on the area of tree and/or forest canopy coverage on the site.

References:
Atlanta, GA: Nowak, D.J. and Crane, D.E. 2000. The Urban Forest Effects (UFORE) Model: quantifying urban forest structure and functions. In M. Hansen and T. Burk, eds. Proceedings: Integrated tools for natural resources inventories in the 21st century. IUFRO Conference, 16-20 August 1998, Boise, ID; General Technical Report NC-212, U.S. Department of Agriculture, Forest Service, North Central Research Station, St. Paul, MN. pp. 714-720.

Carbon Sequestration
CITYgreen's carbon module quantifies the role of urban forests in removing atmospheric carbon dioxide and storing the carbon. Based on tree attribute data on trunk diameter, CITYgreen estimates the age distribution of trees within a given site and assigns one of three Age Distribution Types. Type I represents a distribution of comparatively young trees. Type 2 represents a distribution of older trees. Type 3 describes a site with a balanced distribution of ages. Sites with older trees (with more biomass) are assumed to remove more carbon than those with younger trees (less biomass) and other species. For forest patches, CITYgreen relies on attribute data on the dominant diameter class to calculate carbon benefits.
Each distribution type is associated with a multiplier, which is combined with the overall size of the site and the site's canopy coverage to estimate how much carbon is removed from a given site. The program estimates annual sequestration, or the rate at which carbon is removed, and the current storage in existing trees. Both are reported in tons. Economic benefits can also be associated with

carbon sequestration rates using whatever valuation method the user feels appropriate. Some studies have used the cost of preventing the emission of a unit of carbon—through emission control systems or "scrubbers," for instance—as the value associated with trees' carbon removal services.

Technical Methodology
Estimating urban carbon storage and sequestration requires the study area (in acres), the percentage of crown cover, and the tree diameter distribution. Multipliers are assigned to three predominant street tree diameter distribution types:

Distribution Types Carbon Sequestration Multipliers
Type 1 (Young population) 0.00727
Type 2 (Moderate age population, 10-20 years old) 0.00077
Type 3 (Even distribution of all classes) 0.00153
Average (Average distribution) 0.00335

CITYgreen uses these multipliers to estimate carbon storage capacity and carbon sequestration rates. For example, to estimate carbon storage in a study area:
Study area (acres) x Percent tree cover x Carbon Storage Multiplier = Carbon Storage Capacity
To estimate carbon sequestration:
Study area (acres) x Percent tree cover x Carbon Sequestration Multiplier = Carbon Sequestration Annual Rate

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Appendix C

Summary Table of Non-Market Ecosystem Services for the Lake Simcoe Watershed by Ecosystem Service and Land Cover Type

	Forest	**Grasslands**	**Wetlands**					**Water**	**Agricultural lands**				**Urban Land Cover**		**Total Dollars per Hectare**
Ecosystem Service Functions	**Cool temperate**		**Shallow Water**	**Bog**	**Marsh**	**Swamps**	**Fen**	**Open Water**	**Cropland**	**Pasture**	**Hedgerows/ Cultural woodland**	**Orchards**	**Urban (Impervious)**	**Urban Recreational Areas**	
Gas regulation/Air Quality	$377.14	$12												**$188.57**	**$577.80**
Climate regulation (stored carbon)	$919	$438	$623.35	$968.63	$713.73	$523.84	$1,301.92		$523.18	$464.24	$438.35	$283.58			**$7,198.21**
Climate regulation (annual carbon sequestration)	$39.11	$28.46	$13.02	$13.02	$13.02	$13.02	$13.02			$28.46	$28.46	$28.46			**$218.05**
Disturbance regulation			$4,038.51	$4,038.51	$4,038.51	$4,038.51	$4,038.51								**$20,192.55**
Water regulation	$459	$7												$19.88	**$485.05**
Water supply (filtration)	$209.86		$406.74	$406.74	$406.74	$406.74	$406.74	$197							**$2,440.46**
Erosion control and sediment retention		$50								$5.60	$5.60	$5.60			**$66.88**
Soil formation	$17	$10							$6.06	$6.06	$6.06				**$45.37**
Nutrient cycling										$23.50	$23.50	$23.50			**$70.50**
Waste treatment	$58		$2,148	$2,148	$2,148	$2,148	$2,148								**$10,800.41**
Pollination (agri)	$951	$951								$951	$951				**$3,804.20**
Seed dispersal (birds)	$537														
Biological control															**$-**
Habitat/Refugia			$5,830.88	$5,830.88	$5,830.88	$5,830.88	$5,830.88								**$29,154.42**
Genetic resources															**$-**
Recreation & Aesthetics	$1,231.12	$1,231.12	$1,231.12	$1,231.12	$1,231.12	$1,231.12	$1,231.12	$1,231.12						615.56	**$10,464.51**
Cultural/Spiritual															**$-**
Total per ha $/ha/yr	$4,798	$2,727	$14,292	$14,637	$14,382	$14,193	$14,971	$1,428	$529	$1,479	$1,453	$341	-	$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	-	26,005	3,363	330,741
Total value $M/yr	$319	$22.78	$25	$0.4	$71	$332	$6.8	$103	$51	$36	$5.6	$-	$-	$2.77	$975

Note: Missing values indicate that no data or values are currently available

Appendix D

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