Ontario's wealth Canada's future

APPRECIATING THE VALUE OF THE GREENBELT'S ECO-SERVICES

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SEPTEMBER 2008

Ontario's wealth
Canada's future

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GREENBELT

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Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services

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Disclaimers
This study should be considered a preliminary and coarse-scale natural capital account for the Greenbelt. It is a first step towards a more comprehensive accounting of natural capital assets in the Greenbelt that provides a framework for similar studies across Canada. More Canadian research is needed to determine a full range of ecosystem service values relevant to Canadian eco-zones and land cover types. This work is intended to encourage others to consider the value of natural capital and its ecosystem services, as well as to stimulate a growing dialogue regarding the real value of natural capital, ecosystem services, stewardship, and conservation.

The content of this study is the responsibility of its author and does not necessarily reflect the views and opinions of those acknowledged above.

Every effort to ensure the accuracy of the information contained in this study has been taken. We welcome suggestions for improvements that can be incorporated into later editions of this study.

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CONTENTS

1 **Introduction** | 7

1.1 Ontario's Greenbelt | 7

1.2 Natural Capital and Ecosystem Services | 10

1.2.1 What is Natural Capital? | 10

1.2.2 Valuing Ecosystems | 10

1.3 Global Trends in Ecosystem Services | 12

1.4 Examples of Natural Capital Assessments | 13

1.5 The Value of Watershed Protection: New York City as an Example | 14

1.6 The Role of Natural Capital and Ecosystem Services for Southern Ontario's Sustainability | 15

2 **Land Cover in the Greenbelt** | 16

3 **Ecosystem Values: Southern Ontario Greenbelt** | 19

3.1 The Value of the Greenbelt's Forests Ecosystem Services | 19

3.1.1 The Importance of Forests for Climate Change | 20

3.1.2 Forests as Air Filters and Oxygen Tanks | 21

3.1.3 The Role of Forests for Water Quality and Water Regulation | 23

3.1.4 The Value of Water Run-off Control Services by Forests | 23

3.1.5 The Value of Water Filtration by Forests | 24

3.1.6 The Value of Forests for Recreation | 25

3.1.7 The Value of Forests for Pollination Services | 26

3.1.8 Natural Regeneration: Seed Dispersal Services | 28

3.1.9 Other Annual Forest Values | 28

3.1.10 The Total Value of the Greenbelt's Forests | 29

3.2 Wetlands | 29

3.2.1 The Value of Wetlands as Carbon Banks | 30

3.2.2 The Value of Wetlands for Water Filtration | 30

3.2.3 The Value of Flood Control by Wetlands | 31

3.2.4 The Value of Waste Treatment by Wetlands | 31

3.2.5 The Value of Habitat Provided by Wetlands | 32

3.2.6 The Value of Wetlands for Recreation | 33

3.2.7 The Total Annual Non-market Value of the Greenbelt's Wetlands | 34

3.3 Beach and Sand Dune Ecosystem Values | 35

3.4 Grassland Ecosystem Values | 35

3.4.1 Carbon Values | 35

3.4.2 Other Grassland Ecosystem Values | 36

3.4.3 Summary of Grasslands Ecosystem Values | 36

3.5 Agricultural Lands | 37
3.5.1 Agricultural Lands as a Carbon Bank | 38
3.5.2 Carbon Sequestration Services by Agricultural Lands | 38
3.5.3 Cultural Value of Agricultural Lands | 39
3.5.4 The Value of Hedgerows (Shelterbelts) | 40
3.5.5 The Value of Idle Farmland | 40
3.5.6 Summary of Agricultural Ecosystem Service Values | 41
4 Summary of the Greenbelt's Ecosystem Services | 42
4.1 The Distribution of Ecosystem Values | 43
5 Conclusions | 45
6 Recommendations | 46

Appendix A: Summary Table of Non-Market Ecosystem Services for the Greenbelt by Ecosystem Service and Land Cover Type | 48
Appendix B: Methodology | 49
Purpose of Project | 49
Land Cover Analysis | 49
Identification of Ecosystem Function and Services | 49
Non-Market Ecosystem Valuation | 51
Ecosystem Benefit Transfer Approach | 52
Analysis | 52
Limitations of Current Ecosystem Service Valuation Research | 53
Appendix C: CITYgreen Methods | 54
Endnotes | 57

LIST OF TABLES

Table 1: Ecosystem Functions, Processes and Services | 11
Table 2: Land Cover Area and Per Cent Cover for the Greenbelt | 16
Table 3: The Value of Air Pollution Removed by Trees in the Greenbelt | 22
Table 4: The Value of the Greenbelt's Pollination Services by Natural Cover Type | 28
Table 5: Summary Table of the Greenbelt's Forests Ecosystem Values | 29
Table 6: Summary Table of Wetland Ecosystem Service Values | 34
Table 7: Summary Table of Grassland Ecosystem Values | 36
Table 8: Agricultural Lands in the Greenbelt | 38
Table 9: The Value of Ecosystem Services provided by the Greenbelt's Farmlands | 41
Table 10: Total Value of Greenbelt's Ecosystem Services by Ecosystem Service | 42
Table 11: Summary of Non-Market Ecosystem Service Values by Land Cover Type for Ontario's Greenbelt | 43
Table 12: Summary Table of Non-Market Ecosystem Services for the Greenbelt by Ecosystem Service and Land Cover Type | 48
Table 13: Ecosystem Functions, Processes, and Corresponding Ecosystem Services | 49
Table 14: Ecosystem Services from Different Land Cover and Land Use | 51
Table 15: Non-Market Ecosystem Valuation Techniques | 52

LIST OF FIGURES

Figure 1: Location of Greenbelt in Southern Ontario | 8
Figure 2: Greenbelt Plan Map | 9
Figure 3: Land Cover and Land-use Map for the Greenbelt | 18
Figure 4: Forest Land Cover in the Greenbelt | 20
Figure 5: Forest and Wetland Percent Cover in the Greenbelt's Watersheds | 25
Figure 6: Wetland Area in the Greenbelt | 30
Figure 7: Presence of Rare Species Habitat in the Greenbelt | 33
Figure 8: Loss of Class 1 Agricultural Lands in the Greater Toronto Area and Greenbelt | 37
Figure 9: Agricultural Land use in the Greenbelt | 39
Figure 10: The Distribution of Annual Ecosystem Services per Hectare by Watershed Unit in the Greenbelt | 44

Executive Summary

The Greenbelt, which covers over 1.8 million acres, was designed to safeguard key environmentally sensitive land, watersheds, and farmlands that provide essential ecosystem services for quality of life in this densely populated area of Canada. This protected region includes green space, farmland, communities, forests, wetlands, and watersheds, including habitat for more than one-third of Ontario's species at risk.

> **WHAT IS NATURAL CAPITAL?**
>
> Natural capital refers to the earth's natural ecosystems as stocks or assets that provide resources and a flow of services.

Placing a value on nature

Recognition for the irreplaceable value of ecosystem services and the impact of human development on them is emerging nationally and globally. For instance, the United Nations Millennium Ecosystem Assessment concluded that about 60 per cent of the world's ecosystems are being used at an unsustainable rate. The creation of the Greater Golden Horseshoe Greenbelt is a leading example of land-use planning that protects the essential ecosystem services that sustain air and water quality, local food production, and quality of life for the region. However, public knowledge of the vital role these services play in human life is limited, so it is critical that communities have access to information on the value of natural areas.

This report quantifies the value of the ecosystem services provided by the Greenbelt's natural capital, revealing the annual value of the region's measurable non-market ecosystem services at an estimated $2.6 billion annually; an average value of $3,487 per hectare. This estimated value is likely a conservative estimate, due to the 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. It does, however, provide an estimate of the current benefits of the Greenbelt and the potential costs of human impact if natural capital is depleted.

This report quantifies the value of the ecosystem services provided by the Greenbelt's natural capital, revealing the annual value of the region's measurable non-market ecosystem services at an estimated $2.6 billion annually; almost $8 billion since the establishment of the Greenbelt.

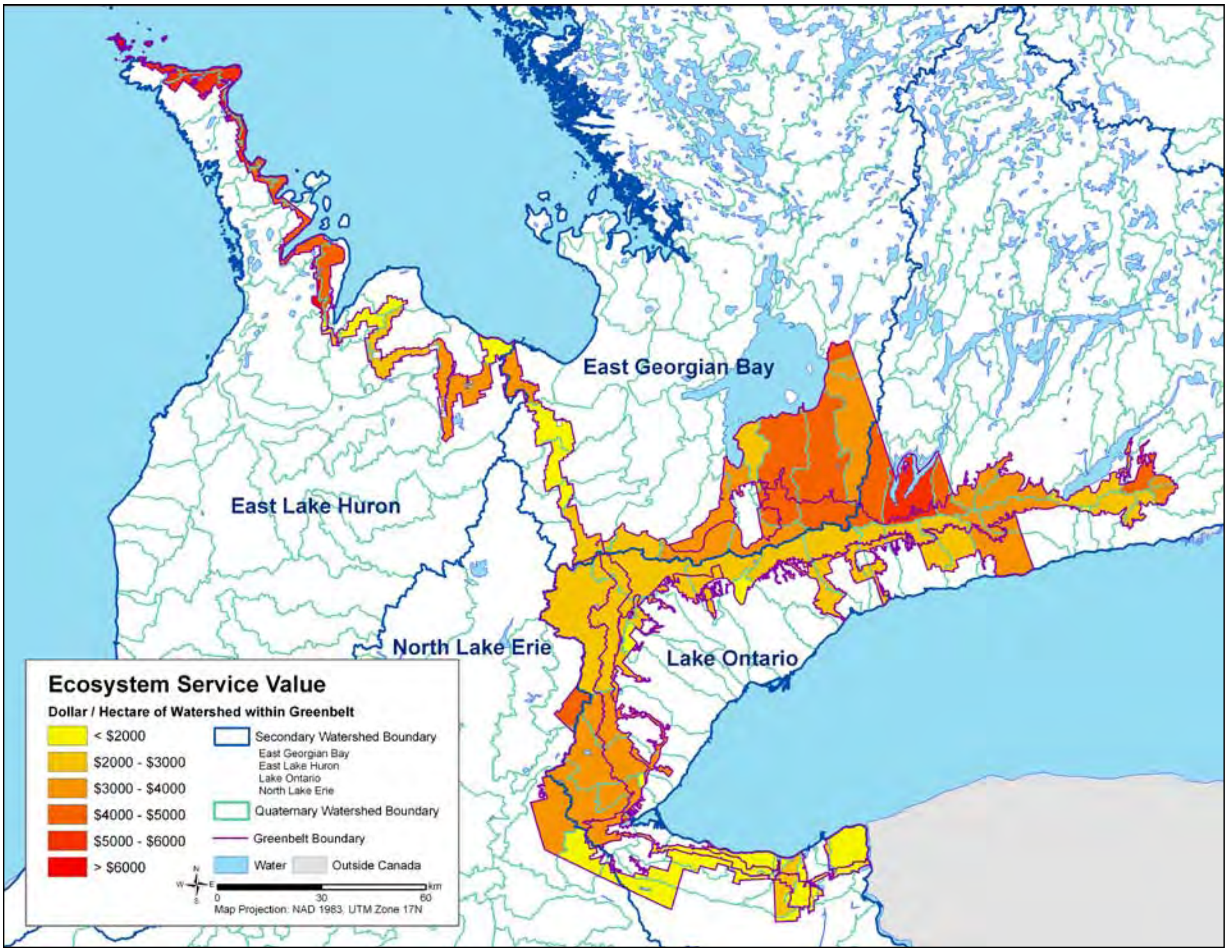
The Greenbelt's wetlands and forests hold the greatest value, worth over $2.3 billion. Wetlands are worth an estimated $1.3 billion per year ($14,153/hectare) because of their high value for water regulation, water filtration, flood control, waste treatment, recreation, and wildlife habitat. Forests provide key services worth $989 million each year because of their importance for water filtration services, carbon storage services, habitat for pollinators, wildlife, and recreation.

The Greenbelt's agricultural lands total value is also substantial at an estimated $329 million per year including cropland, idle land, hedgerows, and orchards. Key values include the pollination value of idle land and hedgerows, the storage of carbon in soils, and the cultural value of agricultural lands.

Non-Market Ecosystem Service Values by Land Cover Type for Ontario's Greenbelt.

LAND COVER TYPE	AREA HECTARES	VALUE PER HECTARE $/HECTARE/YR	TOTAL VALUE $MILLION
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
Cropland	384,378	$477	$183
Orchards	5,202	$494	$2.6
Hedgerows	7,039	$1,678	$11.8
Idle land	78,889	$1,667	$132
Other	42	$0	$0
Total	760,420	$3,487	$2,652

At the watershed level, annual values range from about $2,000 per hectare to greater than $6,000 per hectare. The highest values are in the northern part of the Niagara Escarpment near Georgian Bay, and along the top of the northeast section of the Greenbelt south of Lake Simcoe.



Highlights of ecosystem valuation benefits

CARBON VALUES

The conservation of natural ecosystems is vital because of the carbon they store and the habitat they provide including migration corridors for species as the climate changes. The Greenbelt's forests, wetlands, and soils combined store over 102 million tonnes of carbon worth $366 million per year based on the average damage cost of carbon emissions. The annual carbon uptake is an estimated 167,364 tonnes of carbon, worth $11 million per year.

AIR QUALITY PROTECTION VALUE

Trees are essential for good air quality because they produce oxygen for our air. Each healthy mature tree produces approximately 260 pounds of oxygen every year. Two trees can provide enough oxygen for a family of four. Forests and trees also provide improvements in air quality. They remove gaseous air pollution through leaf absorption, and intercept airborne particles by retaining the particles on their leaves. Each year, the Greenbelt's tree canopy cover removes approximately 60 kilograms of pollutants per hectare. The value of this service is an estimated $69 million per year.

WATERSHED VALUES

The Greenbelt's watersheds are the major sources of water for Lake Ontario in the Golden Horseshoe region. To illustrate the direct correlation between natural cover in a watershed and the level of drinking water quality, the Walkerton Inquiry recommended source protection as one of the most effective and efficient means of protecting the safety of Ontario's drinking water. The total value of the Greenbelt watersheds is $409 million per year including water filtration services provided by forests and wetlands worth an estimated $189 million per year in terms of avoided costs for drinking water treatment. As well, the value of flood control by wetlands is worth an estimated $379 million annually.

POLLINATION VALUE

Approximately 30 per cent of the world's food is from crops that depend on pollinators like bees, insects, bats, and birds. Using 30 per cent as a baseline, the annual value of pollination services for the Greenbelt is estimated at $360 million. Given the significance of natural cover for pollinator biodiversity, nesting habitat, and food and nectar, the total value of pollination services was allocated to idle agricultural lands, grazing lands (perennial croplands), hedgerows, forest lands, and grasslands with an average annual value per hectare of $1,109.

BIODIVERSITY VALUE

Seed dispersal by birds, mammals, and wind is an essential service for the natural regeneration of trees. Based on the average replacement cost, the value for this service is an estimated $537 per hectare per year. For the Greenbelt, this translates to an annual value of $98 million.

RECREATION VALUE

Ontario's annual nature-based recreation is worth $6.4 billion in 2005 dollars based on results from a national survey. The estimated value for the Greenbelt's forests, wetlands, and water is $95 million per year; an annual value of $335 per hectare. The total annual recreational value includes $61 million for forests, $31.5 million for wetlands, and $2.6 million for bodies of water.

AGRICULTURAL LANDS

The annual non-market value of ecosystem services from the Greenbelt's agricultural lands is an estimated $329 million, including cropland, idle land, hedgerows, and orchards. Key values include the pollinator habitat provided by natural cover on idle land and hedgerows, the storage of carbon in farmland soils, and the cultural value of agricultural lands. The annual value for pollination services is $87.5 million on idle lands, $61.8 million on grazing lands, and $7.8 million on hedgerows.

The importance of evaluating ecosystem services

This report is a fundamental step towards measuring the value of ecosystem services provided by the Greenbelt to the eight million residents living in the Greater Golden Horseshoe. This assessment provides total values that will be useful for determining the incremental costs and benefits when making decisions on policy and investments to improve the ability of the Greenbelt to supply ecosystem services that demonstrate the potential benefits of safeguarding the Greenbelt.

Based on the report's finding, the David Suzuki Foundation offers the following recommendations:

1. **Given the ecological value of the Greenbelt, 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.**
2. **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 and work collaboratively with municipalities and conservation authorities – all of whom who have a key role in conserving and enhancing natural capital.**
3. **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.**
4. **Municipalities should work with conservation authorities and local communities to enhance the resiliency of ecosystems and the benefits they provide. This includes wetland creation, tree planting, and environmentally sensitive park and trail creation.**
5. **The provincial government should enhance its financial support for stewardship and other incentive programs that recognize and reward farmers for conservation efforts that protect natural soil, water, air and biodiversity resources of the Greenbelt and their connected ecosystems.**
6. **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 natural capital and its role in providing clean air, clean water, healthy food and wildlife protection.**

The full report can be downloaded at *www.davidsuzuki.org/publications* and at *www.ourgreenbelt.ca*.

Introduction

This report identifies the value of the benefits provided by the Greenbelt's lands and waterways to the more than eight million people living in communities in the Golden Horseshoe. It provides an assessment of the land cover types and quantifies the non-market values of services provided by the Greenbelt's ecosystems.

1.1 Ontario's Greenbelt

Southern Ontario's Golden Horseshoe, located on the western end of Lake Ontario is the most densely populated area in the country, with about a quarter of Canada's population. The Greater Toronto Area and Hamilton (GTAH) is the fastest growing region in North America, where an additional 3.7 million people are expected to live by the year 2031.[1] The rapid increase in population is placing growing pressure on urban expansion into the rural areas.

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 (Figure 1). Its area consists of protected green spaces, farmlands, communities, forests, wetlands, and watersheds.

Figure 1: Location of Greenbelt in Southern Ontario

Greenbelts typically support ecological, cultural, recreational and economic systems near urban areas, and are generally intended to serve as a barrier to urban expansion. In 2005, Ontario's *Greenbelt Act* and Plan established a band of protected area around the GTAH as part of the provincial government's initiative to protect the natural environment and agricultural lands from urban sprawl, and to protect the quality of life in this densely populated region.

The Greenbelt Plan puts into effect the *Greenbelt Act* and includes policies for land use across the Greenbelt (Figure 2), providing protection for agricultural lands and the ecological "green infrastructure" that supports the surrounding urban communities, identifying where urbanization should not occur. The Protected Countryside lands identified in the Greenbelt Plan are additional lands that enhance the extent of protected agricultural and watersheds covered by the Niagara Escarpment Plan (NEP) and the Oak Ridges Moraine Conservation Plan (ORMCP).[2] The Protected Countryside consists of an Agricultural System and a Natural System, together with towns, villages, and hamlets. The Agricultural System is comprised of specialty crop, prime agricultural, and rural areas. The Natural System supports natural heritage features and the protection of watersheds.

GREENBELT VISION (GREENBELT PLAN 2005)

"The Greenbelt is a broad band of permanently protected land which:

Protects against the loss and fragmentation of the agricultural land base and supports agriculture as the predominant land use;

Gives permanent protection to the natural heritage and water resource systems that sustain ecological and human health and that form the environmental framework around which major urbanization in south-central Ontario will be organized; and

Provides for a diverse range of economic and social activities associated with rural communities, agriculture, tourism, recreation and resource uses."

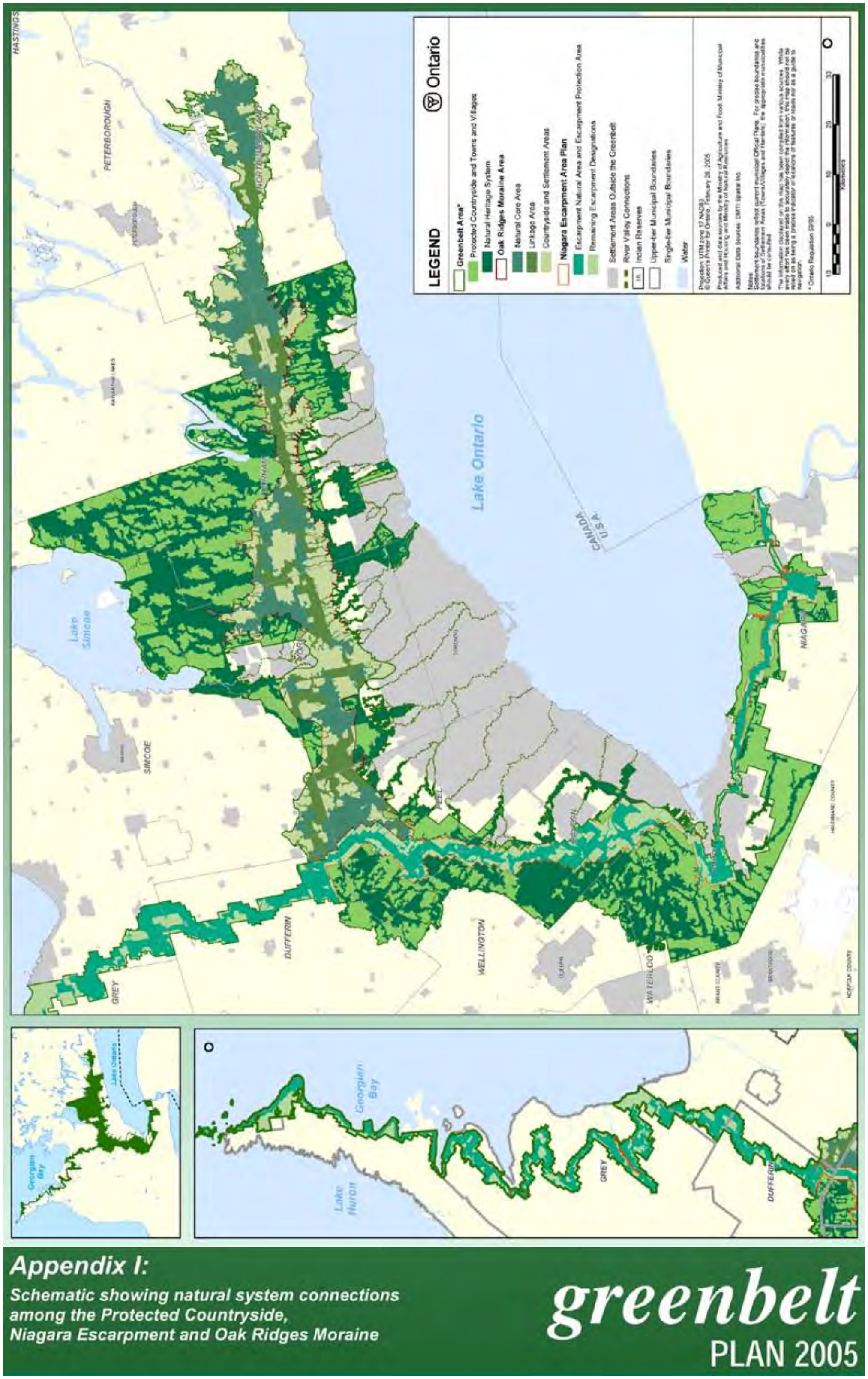


Figure 2: Greenbelt Plan Map

Source: Greenbelt Plan, 2005. Ministry of Municipal Affairs and Housing

The provisions of the Plan do not guarantee the integrity of the Greenbelt's natural capital and ecosystems. The Plan allows for activities related to the use of non-renewable resources, in particular the establishment of aggregate extraction operations such as quarries, under certain conditions. It also permits new projects and additions to infrastructure in recognition that it is a living landscape with some 7,000 working farms and towns and villages. This includes allowing, for example, roads and utility corridors to cross natural heritage features and hydrologically sensitive areas if no practical alternative exists. The Plan's implementation is in large measure the responsibility of municipal governments, who are required to ensure their official plans and decisions on planning applications conform to the policies in the Plan.

1.2 Natural Capital and Ecosystem Services

1.2.1 WHAT IS NATURAL CAPITAL?

Natural capital refers to the earth's natural ecosystems as stocks or assets that provide resources and a flow of services. Natural capital and ecosystem services are the foundation of life – including human life. Forests, wetlands, and rivers are like giant utilities providing ecosystem services for local communities as well as regional and global processes that we all benefit from. The benefits include the storage of flood waters 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.[3] 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.

1.2.2 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. [4] 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)[5]. The following table provides a list of ecosystem functions, processes and the corresponding ecosystem services (Table 1).

The estimated values provided are likely a conservative estimate because the 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 (i.e. the value of nature is priceless). It is also important to note that the value of natural capital and its services will increase over time, as services become increasingly scarce due to global warming and population increase,

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.

for example. The valuations of ecosystem services, however, provide an opportunity to assess the current benefits and the potential costs of human impact.

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 ecosystem services involves identifying the distribution of land and water cover types, and quantifying the benefits, or non-market goods and services, provided by the ecosystems. Natural capital accounting involves establishing accounts that allow the identification and tracking of changes in the provision and value of ecosystem goods and services due to changes in ecosystem land/water cover, as well as the impacts of human activities on the natural environment, such as degradation from pollution and development.

These new tools can be used to assess the current flow of ecosystem services provided to communities and to predict the potential loss in services through conversion of land uses. Ecosystem condition and the services they provide can also be monitored.

1.3 Global Trends in Ecosystem Services

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.

> "Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth."
>
> *Millennium Ecosystem Assessment, 2005*

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. 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.[6] 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. The 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.[7]

One of the main reasons for ecosystem degradation is the exclusion of natural capital in our current measures of progress and decision-making. In general, we measure progress and well-being using an economic indicator – called the GDP (gross domestic product) – as the primary marker of national or provincial performance. 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.[8] For example, the value of a forest in controlling stream-bank erosion and sediment load in a river is not reflected in the market price of forest 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 development result in a problematic scenario where timber is counted as 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 in ecosystem services from pollution, go unaccounted. As a result, the way in which we measure and count our environmental, social, and economic well-being is currently misleading.

1.4 Examples of Natural Capital Assessments

In 1997, a global study estimated the total value of the world's ecosystems goods and services to be worth between $18 and $61 trillion U.S. (2000);[9] an amount similar to the size of the global economy. A follow up study focused on the incremental value of conserving natural capital. The study examined the economic trade-off of conserving a natural area, rather than converting the area for farming or development, in order to protect its ability to supply ecosystem services. This same study concluded that the net value of a hypothetical global reserve network would provide services worth approximately $4.4 trillion per year.[10] The study also estimated the average rate of habitat loss since 1992, finding that the average rate of change globally is -1.2 per cent per year, or -11.4 per cent over 10 years, a loss of about $250 billion each year. The loss of natural areas and their ecosystem services are beginning to be recognized by many jurisdictions taking steps to halt urban sprawl by introducing greenbelt designations, smart growth initiatives, and regulations.

More recently, the World Bank published an assessment of the natural capital asset values of world nations.[11] Canada ranked third in terms of the country's per capita market value including timber, oil, gas, cropland, pasture land, non-timber forest products, and protected areas. This result reflects Canada's real advantage in terms of its expansive natural capital. However, this assessment did not include the non-market values of the services provided by Canada's natural capital, nor did it provide an assessment of the costs to natural capital from extraction, production, and transportation of these products.

Two Canadian studies have considered the economic value of natural capital for Canada's boreal region. The most recent report assessed the natural values of the Mackenzie Region in Western Canada. The study found that the non-market value of the region's natural capital was an estimated $484 billion per year (an average of $2,839 per hectare), 11 times the market value of the region's natural resources.[12] The carbon stored by the Mackenzie watershed was estimated at a value of $250 billion, 56 per cent of the total non-market value. An earlier study that assessed the value of Canada's boreal region included a preliminary estimate for pollution costs and public subsidies for natural capital extraction.[13] These costs were an estimated $11 billion per year for the region, of which air pollution costs were the most costly. These costs reduced the estimated market value of the region's natural capital from $49 billion to $38 billion per year.

"Protection and enhancement of natural capital will improve water quality and decrease water treatment costs, increase recreational opportunities, mitigate flooding, decrease net greenhouse gas emissions, lower dredging costs of waterways, improve air quality, provide habitat, sustain food production and produce many more tangible and intangible benefits to society."

Dr. Nancy Olewiler, *2004. The Value of Natural Capital in Settled Areas of Canada*

A two-year study of the economic value of New Jersey's natural capital was undertaken by the Gund Institute for Ecological Economics in partnership with the New Jersey Department of Environmental Protection in 2006. Their study evaluated the state's ecosystem services based on average values from similar studies covering the types of ecosystems present in New Jersey. Their assessment valued New Jersey's ecosystem services between $11.6 billion and $19.4 billion per year. Wetlands provided the largest dollar value for ecosystem services, followed by marine ecosystems and forests.[14]

A similar study on the economic value of ecosystem services in Massachusetts reported that undeveloped land in the state provides more than $6 billion in non-market ecosystem services annually.[15] The findings concluded that permanent protection of undeveloped land makes economic and ecological sense. This was based on the analysis of losses of forests and agricultural land between 1985 and 1999, which have come at an annual cost of $200 million from losses in ecosystem vale.

1.5 The Value of Watershed Protection: New York City as an Example

"The first barrier to the contamination of drinking water involves protecting the sources of drinking water."

– JUSTICE DENNIS O'CONNOR, WALKERTON INQUIRY 2002

The Food and Agricultural Organization released a report in 2003 stating that the loss of forest cover and the conversion of forests to other land uses can adversely affect freshwater supplies.[16] Studies have shown the importance of protecting watersheds and water sources for regulating water supply and water quality.[17]

The most famous example that demonstrates the value of watersheds, especially for large urban areas, is the Catskill/Delaware watershed and the water it supplies to New York City. The watershed has provided clean water for New York City since 1915, without the need for filtering.

In the early 1990s, the Environmental Protection Agency introduced new requirements for public water systems that mandated the building of filtration systems for unfiltered sources or that water supplies meet certain criteria in order to avoid filtration.[18] 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.[19] The alternative approach would include a comprehensive watershed protection program including land purchase, pollution reduction and conservation easements that would allow the natural ecosystems to purify the water. This would cost 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 based on calculations which determined that protecting the watershed had a better rate of return (90 to 170 per cent) and a shorter payback period of four to seven years.[20] The complex network is the largest unfiltered surface water supply in the world, supplying 1.3 billion gallons of water each day.[21]

1.6 The Role of Natural Capital and Ecosystem Services for Southern Ontario's Sustainability

The Natural Spaces Leadership Alliance, a multi-stakeholder advisory group to the Ministry of Natural Resources, identified the need for a better understanding of the socio-economic benefits of southern Ontario's natural areas.[22] Its 2006 report, Nature Counts, highlighted the: i) economic value of sectors that are dependent on natural capital, such as ecotourism and niche-market agriculture; ii) benefits of nature for human health and well-being; and, iii) economic case for conservation.

It concluded by noting that "finding ways to value greenspace and effectively communicate these values to decision-makers and the public is of critical importance to the future quality of life in Southern Ontario."[23]

The creation of the Greenbelt is a prime example of Ontario's recognition of the need to protect ecosystem services for urban sustainability and local agricultural production. The Greenbelt is a great place for Ontario to begin valuing its natural capital and the benefits provided by its ecosystems. Such information can be used by communities within and around the Greenbelt to access information on the value of their natural capital, and to measure the impact and costs of land-use change.

Our report is designed to provide an assessment of the Greenbelt's natural capital and its non-market ecosystem services. We have focused on non-marketed values for natural capital because they are mostly ignored as socio-economic benefits. The true value of our Earth and its ecosystems is beyond estimation because ultimately nature is irreplaceable. However, we have developed estimates for many of the services provided that can be used for policy, planning, and regulatory decisions. Although there are limitations to monetizing non-market values, their estimation provides an opportunity to assess some of the trade-offs for nature protection and the costs of human impact on the environment.

The following chapters provide:

1. Land cover and land use information for the Greenbelt;
2. The value of ecosystem services provided by the Greenbelt's ecosystems; and,
3. Policy recommendation based on our findings.

"Currently, there is insufficient recognition of the social and economic value of nature. As a result, conservation and stewardship are not appropriately supported by society as a whole, and individual, community and political decisions are made without knowledge of the scope of nature's contribution to southern Ontario's wealth and health."

Nature Counts: Valuing Southern Ontario's Natural Heritage, Ministry of Natural Resources – Natural Spaces Program

The true value of our earth and its ecosystems is beyond estimation because ultimately nature is irreplaceable.

Land Cover in the Greenbelt

The Greenbelt covers more than 1.8 million acres (760,420 hectares) of permanently protected land under the *Greenbelt Act*, 2005. The types of land cover, ecosystems and land use within the Greenbelt are reported here using geospatial land data from the 2000-2002 Southern Ontario Land Resource Information System (SOLRIS; Table 2).[24]

There are three major land types in the Greenbelt: i) agricultural lands (63%), ii) forests (24%), and iii) wetlands (12%). Other land/water cover includes open water such as rivers or streams (1%), and grasslands (0.06%). Urban or built-up areas, roads, and pits and quarries for extraction of resources (73,833 hectares) across the landscape are not part of the protected Greenbelt area.

Table 2: Land Cover Area and Per Cent Cover for the Greenbelt

LAND COVER	LAND COVER TYPE	AREA HECTARES	PER CENT COVER
Agriculture	Mixed Crop	153,705	20%
	Agriculture (NEC)	96,103	13%
	Idle Land	78,889	10%
	Annual Crop	72,731	10%
	Perennial Crop	55,702	7%
	Vineyards	6,137	0.8%
	Orchards	5,202	0.7%
	Hedge Rows	7,039	0.9%
	Total	**475,508**	**63%**
Forest	Deciduous Forest	84,681	11%
	Mixed Forest	46,475	6%
	Coniferous Forest	33,330	4%
	Plantations – Tree Cultiv	17,875	2%
	Forest	296	0.04%
	Total	**182,657**	**24%**
Wetlands	Swamp	82,459	11%
	Marsh	10,225	1%

Table 2: Continued

LAND COVER	LAND COVER TYPE	AREA HECTARES	PER CENT COVER
Wetlands	Shallow Water	571	0.08%
	Bog	40	0.01%
	Fen	181	0.02%
	Total	**94,014**	**12%**
Waterbodies	**Total**	**7,821**	**1.0%**
Grasslands	Open Tallgrass Prairie	122	0.02%
	Tallgrass Woodland	312	0.04%
	Tallgrass Savannah	7	0.001%
	Total	**441**	**0.06%**
Other	Sand Barren	42	0%
Greenbelt	**Total Area**	**760,420**	**100%**
Urban Built-up/ Roads/Extraction	Transportation	24,874	
	Built-Up Area Impervious	34,560	
	Built-Up Area Pervious	6,261	
	Extraction	8,138	
	Total	**73,833**	

The distribution of land cover and land use across the Greenbelt is illustrated in Figure 3. This map shows land cover for the Oak Ridges Moraine, Niagara Escarpment, and Protected Countryside areas within the Greenbelt.

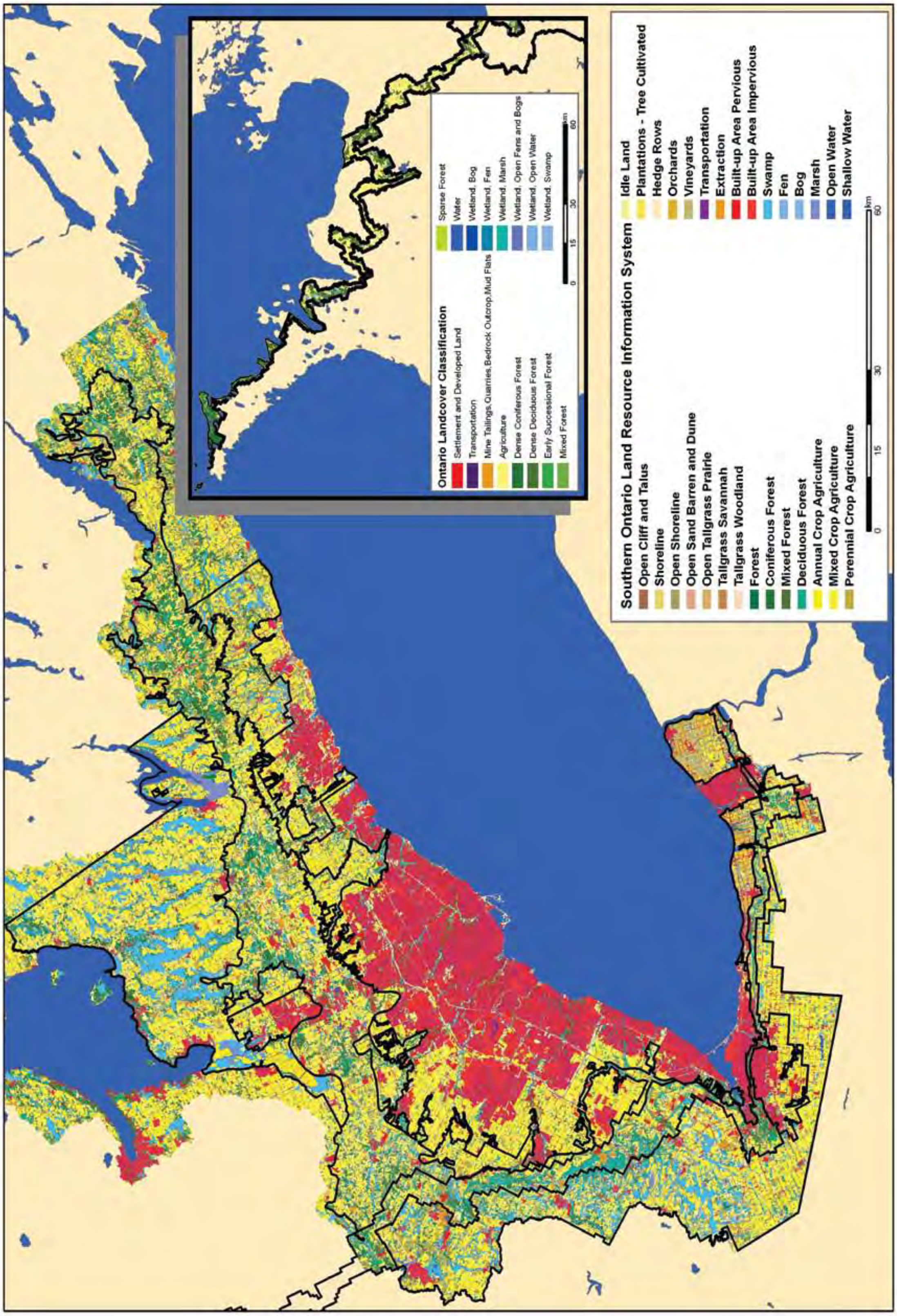


Figure 3: Land Cover and Land-use Map for the Greenbelt

Ecosystem Values: Southern Ontario Greenbelt

3.1 The Value of the Greenbelt's Forests Ecosystem Services

Forest ecosystems are a significant part of Ontario's natural capital, providing numerous ecosystem services. Forests and trees provide a wide range of environmental and economic benefits. They capture and clean our water and air; reduce air pollution and mitigate climate change; provide shade for buildings and people; and provide endless supplies of oxygen. Forests and wetlands play an integral role in the global carbon cycle by storing carbon from the atmosphere. These ecosystems provide large terrestrial banks of carbon and prevent increases in the level of greenhouse gases in the atmosphere. As a result, large amounts of carbon are stored in a forest's trees, plants, roots, and soils.

International studies have estimated that temperate forests are worth, at a minimum, $2,000 per hectare per year given the important services they provide.[25] A recent assessment of Canada's boreal ecosystem services estimated that the annual benefits of intact boreal forests and peatlands are worth at least $665 to $5,300 per hectare, respectively.[26] In general, the most significant forest values are carbon storage, water supply, and air quality.

The following sections (Figure 4) detail the valuation for each ecosystem service provided by the Greenbelt's 182,594 hectares of forest.

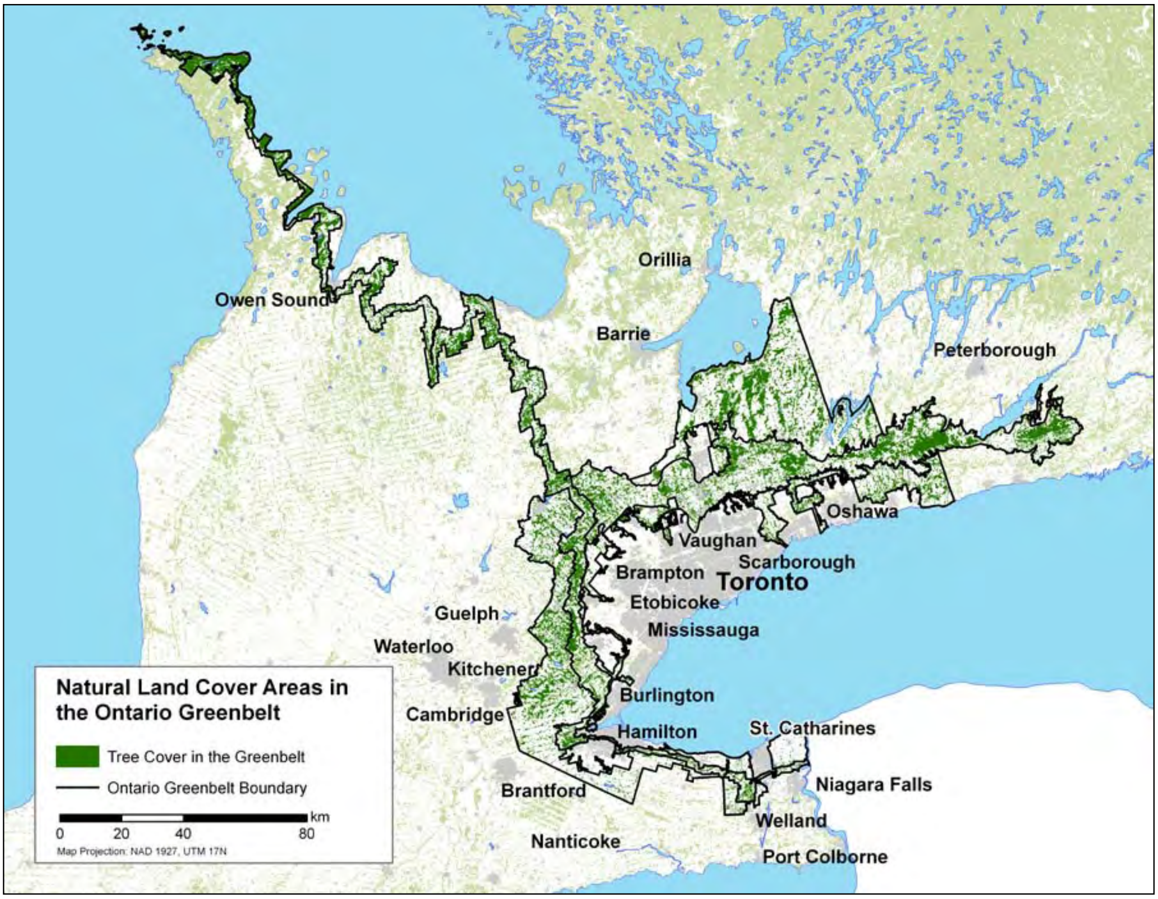


Figure 4: Forest Land Cover in the Greenbelt

3.1.1 THE IMPORTANCE OF FORESTS FOR CLIMATE CHANGE

Maintaining the integrity of natural ecosystems is important for conservation and for climate change mitigation and adaptation purposes. As the climate continues to change, the conservation of natural ecosystems will become even more vital because of their immense stores of carbon, and for their provision of species habitat and migration corridors. When a forest is converted to a field or a housing development, the disturbance of natural vegetation and soil results in the rapid release of carbon dioxide to the atmosphere. Consequently, protecting the carbon stores that exist in our natural ecosystems will minimize the loss of ecosystem carbon.

3.1.1.1 Forest Ecosystems as Carbon Banks

Globally, forest ecosystems contain more than half of all terrestrial carbon and account for approximately 80 per cent of the exchange of carbon between terrestrial ecosystems and the atmosphere.[27] Forests store enormous amounts of carbon in standing trees and in the soil because of their cumulative years of growth.[28] Carbon storage and annual carbon sequestra-

tion 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.

Southern Ontario's forests are part of the Cool Temperate (CT) eco-climatic zone with some pockets in the Moderate Temperate (MT) zone. The CT and MT zones store, on average, 220 and 340 tonnes of carbon per hectare, respectively.[29] Most of the Greenbelt is within the CT zone, so this report uses an average of 220 tonnes per hectare of forest for calculations. Based on this average carbon content, the total carbon stored by the Greenbelt's forests is an estimated 40 million tonnes of carbon, or 147 million tonnes CO_2e (carbon dioxide equivalent).[30] This is the equivalent of the energy used by 13 million households over one year, or 27 million cars driven over one year.[31]

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, at US$43 per tonne of carbon ($52/tC in 2005 Canadian dollars).[32] Using this value, the carbon stored by the Greenbelt is worth $1.7 billion (C$2005).[33] In order to assess the annual value, the carbon stored by forests was considered as an annuity investment over 20 years. Thus, the total annual value of carbon stored by the Greenbelt's forests is $167.9 million or $919 per hectare.[34]

3.1.1.2 The Value of Annual Carbon Uptake by Forests

The annual uptake of carbon (i.e. net carbon sequestration) was calculated using CITYgreen software.[35] CITYgreen's carbon module quantifies the removal of carbon dioxide by trees based on the estimated age distribution by assigning three Age Distribution Types. Type 1 represents a distribution of young trees, type 2 represents older trees, and type 3 describes a site with a balanced distribution of ages. Each type is associated with a multiplier (i.e. tonnes of carbon taken up per hectare), which is combined with the overall area of the site's canopy to estimate how much carbon is removed (also see Appendix C).

Based on the total tree canopy cover area, the carbon annually sequestered is approximately 137,000 tonnes of carbon, or an annual average of 0.75 tonnes of carbon per hectare. The annual value is $7 million per year or $39 per hectare based on the global average cost of carbon emissions (C$52/tC).

3.1.2 FORESTS AS AIR FILTERS AND OXYGEN TANKS

Forests and trees provide many environmental and economic benefits that contribute to improved environmental quality and human health. These benefits include improvements in air and water quality, fish habitat, and cooler air temperatures. In developed areas, trees also reduce building energy use, ultraviolet radiation levels and noise. Urban sprawl that expands into forested regions results in trees and forests being replaced with compacted soils, buildings, roads and cars. Consequently, the shift from forest to urban land uses changes the downwind and downstream environment, which impacts regional air and

water quality.[36] Thus, the conservation and expansion of forests in and around urban and suburban areas is critical to air and water quality.

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 environmental damages in southern and central Ontario.[37] Fifty per cent of this cost is from trans-boundary air pollution (e.g. from U.S. emissions), and the remainder is from Ontario's air pollution emissions. Seventy per cent of the total damages ($6.6 billion) are due to health costs and 30 per cent ($3 billion) is from environmental costs.

The 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. Full costs are likely higher as damages to aquatic ecosystems are not included.

Trees are essential for good air quality because they produce oxygen for our air. Each healthy mature tree produces about 260 pounds of oxygen every year. Two trees can provide enough oxygen for a family of four.[38] Forests and trees also provide improvements in air quality. Trees remove gaseous air pollution by absorption through their leaves and they also intercept airborne particles by retaining them on their leaves. Studies show that trees can remove eight to 12 grams of air pollutants per square metre of canopy.[39]

CITYgreen software was used to assess the amount of air pollutants removed by the tree canopy cover across the Greenbelt. CITYgreen calculates the value of air cleansing by trees using average removal rates of carbon monoxide, nitrogen dioxide, nitrogen dioxide, particulate matter and sulphur dioxide by trees (see Appendix C). This report shows that the Greenbelt's trees remove about 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 $69 million per year, or $377 per hectare.

Table 3: The Value of Air Pollution Removed by Trees in the Greenbelt

	KILOGRAMS PER HECTARE	VALUE PER KILOGRAM	VALUE PER HECTARE	TOTAL VALUE $ PER YEAR
Carbon monoxide	1.2	$1.04	$1.25	$228,622
Ozone	30.3	$7.51	$227.59	$41,557,405
Nitrogen Dioxide	7.5	$7.51	$56.34	$10,286,486
Particulate Matter	16.8	$5.01	$84.25	$15,383,852
Sulphur Dioxide	4.2	$1.83	$7.71	$1,407,122
Totals	60.0	$6.29	$377.14	$68,863,488

Note: the total tree cover is based on the total forest area of 182,594 hectares

3.1.3 THE ROLE OF FORESTS FOR WATER QUALITY AND WATER REGULATION

Water is critical for all life. A safe and reliable source of water for all human use is important, both now and in the future. Water pollution comes from point sources such as industrial discharges and wastewater treatment plants. It also is derived from non-point sources including runoff from agricultural lands and facilities, urban areas, construction sites, and failed septic tanks. In the United States, damages to streams, lakes and estuaries from non-point source pollution have been estimated to cost between $7 billion and $9 billion each year.[40]

Poor water quality degrades recreational areas and fish habitats, which affects human health by increasing insect and waterborne diseases. It also leads to odour problems and diminished aesthetic values. Forests and wetlands can reduce non-point source water pollution because they filter, store, and transform pollutants into non-harmful forms.

Forests 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. In other words, changes in stream flow due to forest loss results in: 1) lower water levels in dry seasons, 2) higher than normal water levels in wet seasons or storms, 3) greater amounts of sediment entering rivers, and 4) increased water temperatures.[41]

Field research demonstrates forests and tree cover significantly improve water quality. 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 microorganisms filter out pollutants.[42] This filtering significantly reduces the sediment, pollutants and organic matter that reach streams. Riparian forests (i.e. forested buffers along waterways) are especially effective at reducing non-point source pollution, such as nitrogen and nitrates in runoff and trapping sediment.

3.1.4 THE VALUE OF WATER RUN-OFF CONTROL SERVICES BY FORESTS

The value of water regulation by forests is calculated as a replacement value using the CITYGreen software (see Appendix C). Analysis of the Greenbelt's total forest cover was assessed in terms of the replacement construction costs for water runoff control if the current forest cover was removed and converted for urban land use. In other words, the forest cover provides savings because it provides green infrastructure for the region. The total annual savings are $223 million or $1,523 per hectare.[43]

Scenario analysis was also undertaken to assess the costs of losing 10 per cent of the current forest cover in the Greenbelt due to conversion to urban land use. In this scenario, the replacement costs for the natural service of water run-off control would be $27 million per year.

Protected forests provide higher quality water with less sediment and fewer pollutants than water from watersheds with unprotected forests.[45]

3.1.5 THE VALUE OF WATER FILTRATION BY FORESTS

Ontario's drinking water comes from lakes, rivers, streams or underground sources (aquifers). All of these sources are linked in a watershed by the ecosystems that capture, filter and deliver water. The best way to protect sources of water is through watershed planning because water flows cross traditional boundaries such as towns and cities. The Walkerton Inquiry recommended source protection as one of the most effective and efficient means of protecting the safety of Ontario's drinking water.[44]

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.[46] A U.S. study concluded that the cost of treatment for surface water supplies varies depending on the per cent forest cover in the water source area.[47] They found 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.

We used the results from this study to interpret the value of the Greenbelt's current forest cover for water filtration services. First, we assessed the proportion of forest 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.[48] The East Lake Huron watershed has 51 per cent forest and wetland cover; the Eastern Georgian Bay has 29 per cent forest and wetland cover; North Lake Erie has 21.7 per cent forest and wetland cover, and Lake Ontario watershed has 24.5 per cent forest and wetland cover (Figure 5). Forest and wetland cover was greatest across the Niagara Escarpment region of the Greenbelt where forest and wetland cover is 40 per cent, with much lower proportions in the Oak Ridges Moraine (21%) and the protected countryside (27.5%). The average natural cover by forests and wetlands in the Greenbelt is approximately 30 per cent.

The value of the water filtration services by forest and wetland cover is calculated based on the statistical correlation found by the U.S. study mentioned above. As well, the value is determined by the potential increase in water treatment costs if the current forest/wetland cover in the Greenbelt declined from its current average of 30 per cent to 10 per cent. Based on the current cost for water treatment currently for the City of Toronto ($0.60 per cubic metre), our analysis shows that 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 is the avoided cost or the value of maintaining the current forest and wetland cover.

About half of the Greenbelt watersheds flow into Lake Ontario, 46 per cent into Lake Huron and five per cent into Lake Erie. If we transfer the value for water filtration from the Lake Ontario watershed ($474/ha/year) to all forest and wetland cover in the Greenbelt (276,608 hectares), the annual value of water filtration services is 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 (see wetland section).

For comparison's sake, it is enlightening to consider the total replacement cost for water. If the daily residential water use in the GTAH had to be replaced by bottled water, the daily cost would be $2.2 billion (1,508 million litres at $1.50 per litre), or $825 billion per year.

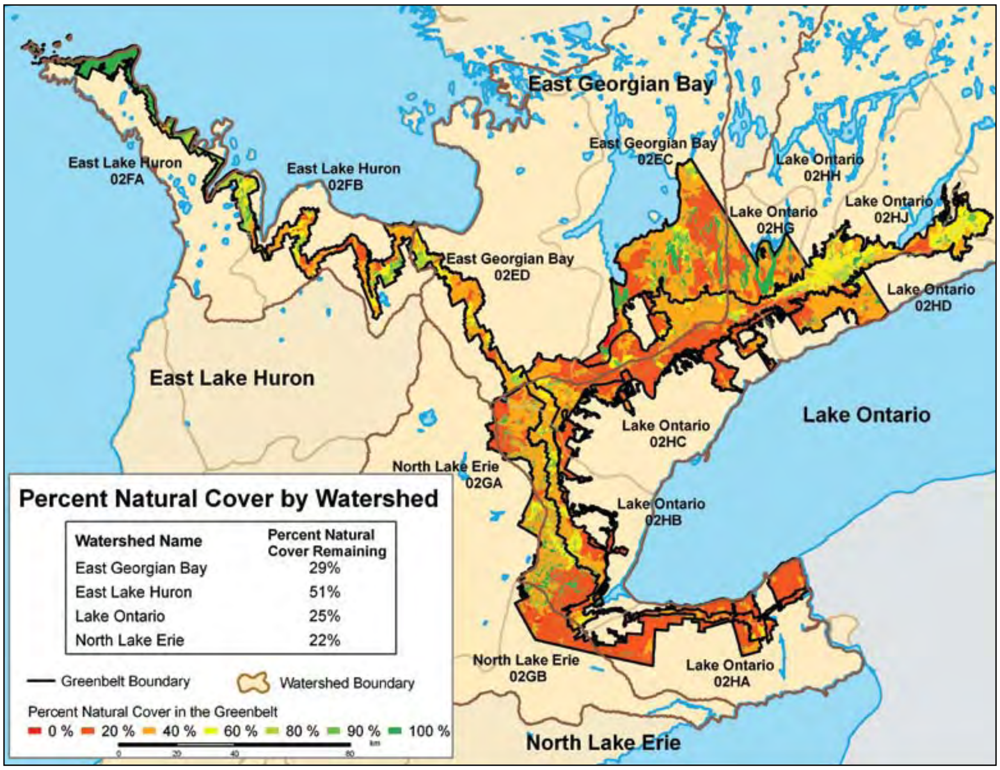


Figure 5: Forest and Wetland Percent Cover in the Greenbelt's Watersheds

3.1.6 THE VALUE OF FORESTS FOR RECREATION

The Greenbelt is important for tourism, recreation, and healthy living. More than half of the people living in central Ontario are likely to take advantage of the tourism and recreation possibilities of the Greenbelt (i.e. hiking, camping, skiing, fruit-picking, wine-tasting, holiday tours, and spas).[49] In 2004, tourists' expenditures contributed $21.4 billion to the provincial economy and tourism employment in Ontario reached 205,700 jobs.[50]

More than half of the people living in central Ontario are likely to take advantage of the tourism and recreation possibilities of the Greenbelt.

Ontario's Greenbelt has Canada's largest network of hiking trails, which links the oldest and longest marked footpath, the Bruce Trail with the Oak Ridges Moraine Trail. Using this network, one could walk from Rice Lake in the East to Tobermory in the North, to Queenston in the South and along the Niagara River. More than 400,000 people hike the Bruce Trail each year. Trails in the Greenbelt also include trails in conservation areas and municipal parks.

In addition, there are two national parks and six provincial parks that provide recreation for hikers, campers, and outdoor enthusiasts. The Bruce Peninsula National Park is part of the Niagara Escarpment, which spans 725 km from Niagara to Tobermory. In 1990, the Escarpment was designated as a UNESCO World Biosphere Reserve due to its unique ecosystems.[51]

Bee pollination is essential for food production and biodiversity, and therefore vital to natural and semi-natural ecosystems.

The value of recreation is based on a 1996 national survey that estimates the economic impact of nature-based recreation and the willingness to pay for nature-based activities.[52] Ontario's annual nature-based recreation value from the 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 is an estimated $335.[53] Based on this value, the total annual recreational value for forests in the Greenbelt is $61 million. This value is also used to measure the recreation services for the different wetland and water cover types in the Greenbelt.

3.1.7 THE VALUE OF FORESTS FOR POLLINATION SERVICES

Pollination is the transfer of pollen from one flower to another, which is critical for fruit and seed production in most plants. About 80 per cent of all flowering plant species are dependent on pollination, making it critical to the overall maintenance of biodiversity. Without this service, many interconnected species and ecosystem functioning within an ecosystem would collapse.[54] In Canada, there are more than 1,000 species of pollinating insects.[55]

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 comes from crops that depend on pollinators like bees, insects, bats, and birds.[56] In fact, the service of bee pollination is worth up to 100 times more than the value of their honey.[57] For example, each wild blueberry bee pollinates 15-19 litres of blueberries – a value so great to blueberry farmers that they call them "flying $50 bills". The value of bee pollination for crops in Canada has been conservatively estimated at $1.2 billion per year.[58] Globally the value of pollinators for food production ranges from $112 to $200 billion each year. In the United States, the economic value of all pollinator services for agriculture is an estimated $5.7 to $13.4 billion per year.[59]

Honeybees provide about 90 per cent of managed pollination services, but a range of new research shows how pollinators can add significant value to a crop:

- In the United States alone, the annual contribution of wild pollination services is estimated at more than $3 billion annually.[60]
- In Costa Rica, wild bees increased coffee yields by 20 per cent, increasing crop values by up to $393 per hectare.[61]
- Tomatoes do not require an animal pollinator, however, visits by bumblebees can increase fruit set by 45 per cent and fruit weight by 200 per cent.[62]
- Wild bees enhance the pollination services of honeybees to produce hybrid sunflower seeds because they are more likely to jump rows, bringing together the male and female genes.
- In Canada, enhanced pollination services produce larger and more symmetrical apples in orchards, providing marginal returns of five to six per cent or $250 per hectare.[63]

Many pollinators are in decline largely due to habitat destruction, which negatively impacts nesting and mating sites, food sources, and health. Diverse habitats that provide a variety of flowers provide the best forage for pollinators. Flower-rich field borders, windbreaks such as hedgerows, forests and riparian buffers encourage a wide variety of pollinators.[64]

The use of pesticides has also contributed to declines in pollinators. Even at low levels, pesticides affect longevity, memory, navigation, and foraging abilities of honeybees.[65] According to Environment Canada, pesticide-use across North America has doubled since 1960.[66] Herbicides used on lawns and gardens as well as rural lands, eliminate the natural plants that wild pollinators need before and after crops are in bloom. The spread of invasive pests such as mites and parasites have also negatively impacted bees. As insect populations decline, the fruit and vegetable yields and the wild plants that depend on pollinators also decrease.

As wild pollinators have declined, their pollination services have had to be replaced by beekeepers that transport their bees from area to area for paid "contract" pollination services to farmers. However, managed honeybees have also been impacted by natural habitat and forage losses as well as increases in mites and parasites, so their colonies have also been declining.[67] In the United States, about half of the managed and wild honeybee colonies have been lost since 1945. However, just in the past couple of years declines have intensified. During the 2006-2007 winter, one-third of North America's beehives disappeared.[68] The decline in honeybees has meant that many farmers have had to rely increasingly more on wild pollinators.

Many modern agricultural practices actually limit crop productivity by harming pollinators. Studies have shown that intensive agricultural activities are correlated with the decline in populations and diversity of pollinators in apple orchards in British Columbia and berry production areas.[69] Farmers can alleviate some of these impacts by not spraying during crop bloom and by diversifying crops to attract a variety of pollinators. It is also important that non-crop plants and trees in nearby forests, meadows, hedgerows, and field borders are left as bee habitat and forage.

Several studies have documented the significance of natural habitat in close proximity to growing crops 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.[70] Similarly, studies that examined pollination and surrounding land use for tomato and sunflower production found that natural habitat near farms increases pollination services.[71]

Based on the importance of natural cover and habitat for both honeybee and wild pollination services, we analyzed the proximity of cropland to forest cover in the Greenbelt: 30 per cent of agricultural land is within 100 metres, 43 per cent is within 200 metres and 50 per cent is within 300 metres of wooded areas. We also analyzed the proximity of agricultural lands to natural cover. Results indicate that 96 per cent of the Greenbelt's agricultural lands have 20 to 60 per cent natural cover within a two kilometre radius (46 per cent have 20 per cent natural cover, 40 per cent have 40 per cent natural cover, and 10 per cent have 60 per cent natural cover).

The annual value of pollination services for the Greenbelt is an estimated $360 million, based on the global average of crop production that is dependent on pollination. This proxy value was calculated by multiplying the total value of farm crop production for the Greenbelt ($1.2 billion 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, forest lands, and grasslands with an average annual value per hectare of $1,109 (Table 4). Forest lands represent 56 per cent of this natural cover for pollinators, therefore they provide a value of $202 million per year.

Table 4: The Value of the Greenbelt's Pollination Services by Natural Cover Type

NATURAL COVER	AREA HECTARES	PER CENT OF NATURAL COVER AREA	POLLINATION SERVICES $/HA	TOTAL VALUE $MILLIONS
Idle Land	78,889	24%	$1,108.83	$87.5
Hedge Rows	7,039	2%	$1,108.83	$7.8
Total forest	182,594	56%	$1,108.83	$202.5
Total grassland	441	0.1%	$1,108.83	$0.5
Grazing lands	55,702	17.2%	$1,108.83	$61.8
Total natural cover	324,666	100%	$1,108.83	$360.0

3.1.8 NATURAL REGENERATION: SEED DISPERSAL SERVICES

Seed dispersal by birds, mammals and wind is an essential service for the natural regeneration of trees. Our estimate is based on the value from a study that determined the replacement costs for the seed dispersal services performed by one bird species (Eurasian jay) in the Stockholm National Urban Park. This study estimated the costs of replacing this service through human planting. Their study determined that natural regeneration of oak trees by birds was worth between $2,100 and $9,400 per hectare.[72] Not all seeds are dispersed by birds. Whether they are dispersed by birds or other methods, the replacement cost would still be human-based. This value was used as a proxy for this service at $537 per hectare per year based on the avoided cost of replacing the services (total annual value of $98 million).

3.1.9 OTHER ANNUAL FOREST VALUES

Forests provide a range of other benefits that can be quantified as follows:

- Based on a global natural capital study, the annual value of soil formation by temperate forests is $17 per hectare.[73]
- According to a southern Ontario study for the Grand River Watershed, the annual value of waste treatment services by forests (i.e. removal of phosphorus and nitrogen) is estimated at $58 per hectare.[74]
- Biological control refers to the pest control service provided by forest birds based on a study by the U.S. Forest Service. Their study estimated the annual cost to replace the services of birds in forests with chemical pesticides or genetic engineering at $25.97 per hectare.[75]

3.1.10 THE TOTAL VALUE OF THE GREENBELT'S FORESTS

The overall total annual value of the Greenbelt's forests is estimated at $989 million, or $5,414 per hectare (Table 5).

Table 5: Summary Table of the Greenbelt's Forests Ecosystem Values

ECOSYSTEM SERVICE FUNCTIONS	VALUE $/HA/YEAR	TOTAL $MILLIONS
Air Quality	$377.14	$68.9
Climate regulation (carbon stored)	$919	$167.9
Climate regulation (annual carbon uptake)	$39.11	$7.1
Water runoff control	$1,523	$278.1
Water filtration	$473.98	$86.5
Erosion control and sediment retention	n/a	n/a
Soil formation	$17	$3.2
Nutrient cycling	n/a	n/a
Waste treatment	$58	$10.6
Pollination (agri)	$1,109	$202.5
Pollination (trees)	$537	$98.0
Biological control	$25.97	$4.7
Habitat/Refugia	n/a	n/a
Genetic resources	n/a	n/a
Recreation & Aesthetics	$334.73	$61.1
Cultural/Spiritual	n/a	n/a
Total forest area (ha) 182,594		
Total C$(2005)	$5,414	$988.6

3.2 Wetlands

Wetlands are a dominant feature of the Canadian landscape, covering approximately 14 per cent of Canada's land. Wetlands provide essential services such as storing, purifying and supplying fresh water, storing carbon, absorbing pollutants and supporting numerous species of plants and wildlife, many of which are identified as species at risk.

About 2.4 million hectares of wetlands covered the southern Ontario landscape, prior to European settlement (25 per cent of southern Ontario). The highest concentration of wetlands occurred in southwestern and eastern Ontario where 40 to 80 per cent of the area was wetland.[76] Studies indicate that about 70 per cent of the original wetland cover has been lost across southern Ontario.[77] Most of the wetlands were drained for agricultural land use. Today, wetlands cover 94,014 hectares of the Greenbelt (12 per cent of the total area; Figure 6).

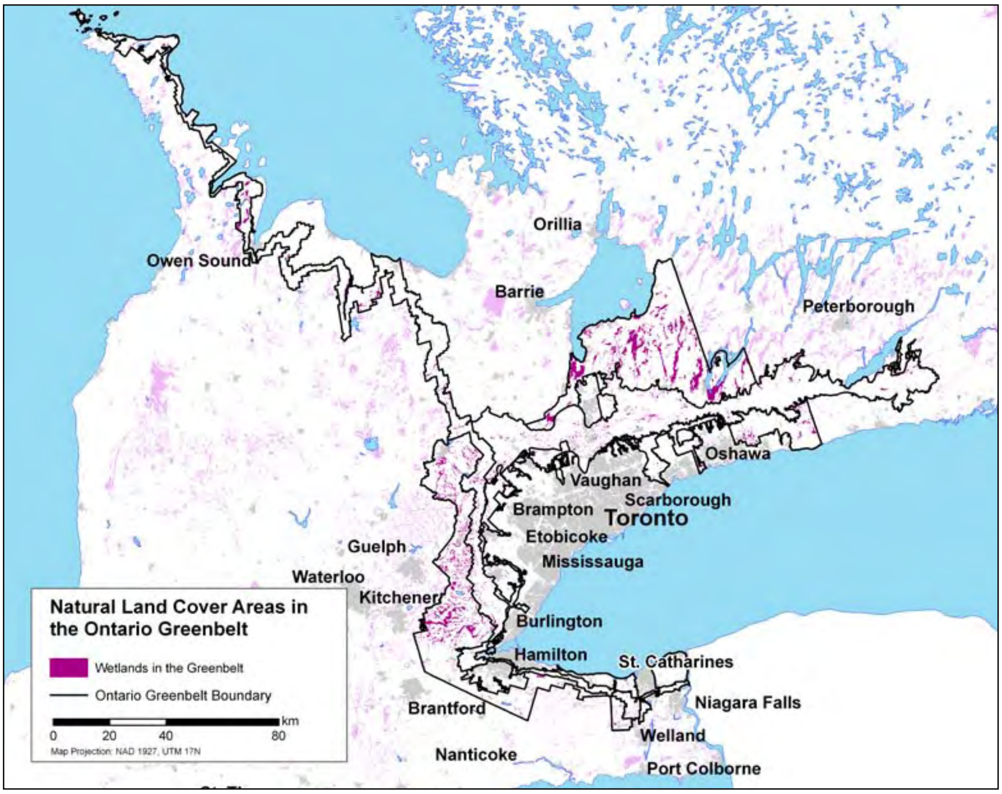


Figure 6: Wetland Area in the Greenbelt

3.2.1 THE VALUE OF WETLANDS AS CARBON BANKS

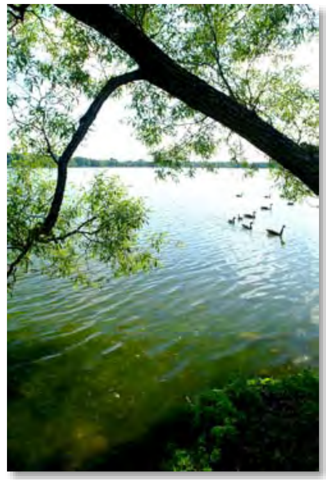
Wetland carbon storage was determined using Canada's Soil Organic Carbon Database.[78] According to this database, the Greenbelt's wetlands store 6.7 million tonnes of carbon in their soils and peat. The annual value of the carbon stored is an estimated $41.8 million based on the average damage cost of carbon emissions ($52/tonne of carbon), over 20 years. The value per hectare ranges from $429 to $1,360 per hectare depending on the type of wetland (i.e. open water, bog, marsh, swamp and fen).[79]

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 (0.25 tonnes per hectare per year),[80] the annual rate of carbon uptake is worth an estimated $13 per hectare ($1.2 million per year).

This represents a very conservative estimate because other studies have found higher rates of carbon uptake, and the carbon uptake by wetland plant cover is not included. For instance, a marsh field study in the Ottawa River Valley found annual net carbon uptake rates of 0.7 tonnes per hectare.[81]

3.2.2 THE VALUE OF WETLANDS FOR WATER FILTRATION

As reported in the forest section of this report, a study by The Trust for Public Land and the American Water Works Association (AWWA) demonstrates that the cost of water treatment varies depending on the percentage of forest cover in the water source area.[82]



According to this study, water treatment costs are, on average, 20 per cent more for each 10 per cent loss in forest cover. In other words, where forest cover is low, water treatment costs more. Because wetlands are integral to forest cover and water quality, wetland and forest cover were included.

The value for water filtration is based on the potential increase in water treatment costs if the forest/wetland cover in the Greenbelt watersheds declined from its current 30 per cent to 10 per cent. The avoided cost is $188.5 million per year, which translates to an annual value per hectare of $474 based on the current forest/wetland cover in the Lake Ontario watershed within the Greenbelt (397,710 hectares; 30 per cent of the watershed).[83]

If we transfer this value for water filtration from the Lake Ontario watershed ($474/ha/year) to all forest and wetland cover in the Greenbelt (276,608 hectares), the annual value of water filtration services is an estimated $131 million. Of this total, $86.5 million is attributed to forest cover in the Greenbelt and $44.6 million due to wetland cover (see section 3.1.5 for a more detailed description).

3.2.3 THE VALUE OF FLOOD CONTROL BY WETLANDS

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.[84]

The annual value of flood control by wetlands is based on an average ($4,039 per hectare of wetland) derived from four different studies.[85] Based on this average, the annual value of wetlands for flood control is estimated at $380 million.

3.2.4 THE VALUE OF WASTE TREATMENT BY WETLANDS

Wetlands are effective waste treatment systems. In fact, constructed wetlands are at times used to treat human and agricultural wastes. They can absorb nutrients such as nitrogen and phosphorus that run off farmlands. 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.[86] Greenbelt riparian wetland cover has the capacity to remove 5.2 million kilograms of phosphorus and 22.7 million kilograms of nitrogen each year, based on the low-end removal rates.[87]

Agricultural environmental indicators are reported for census years 1981 to 2001 by Agriculture and Agri-Food Canada (AAFC). The residual soil nitrogen on farmlands and the risk of water contamination by nitrogen from farmlands are two indicators in this series of reports. Residual soil nitrogen (RSN) is the amount of nitrogen (N) that has been applied to soils but not removed by the harvested portion of crops. In other words it is the difference between all nitrogen inputs, such as fertilizer, manure and natural processes, and the nitrogen removed both by the crops harvested and natural processes (volatilization and denitrification).[88] Between 1981 and 2001, farmland in Ontario, on average, has been in the

moderate RSN category (20 to 30 kg N/ha). However, a dramatic increase in the proportion of farmland in the high and very high classes was reported in 2001. In total, 81 per cent of farmland had high or very high RSN, including 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. The increase is due to relatively high manual nitrogen inputs (112 kg N/ha), increased soybean and alfalfa crops (high biological fixation of nitrogen), and an increased number of livestock in Ontario (i.e. nitrogen inputs from manure).[89]

The second indicator measures the risk of water contamination by nitrogen (IROWC-N). Nationally, nitrate loss increased by 25 per cent from 6 kg/ha in 1981 to 7.6 kg/ha in 2001, and nitrate concentration in water was 24 per cent higher in 2001 than 1981.[90] In Ontario, there was a dramatic increase in 2001 relative to the previous census years. Prior to 2001, more than 60 per cent of the farmland was in *very low* and *low* risk classes. In 2001, 73 per cent of farmland was reported as *high* risk (10 to 20 kg N/ha) plus an additional 8 per cent as *very high* risk (greater than 20 kg N/ha).

The estimated nitrogen loss from Greenbelt croplands is 2.8 to 5.6 million kilograms per year, based on an annual loss of 10 to 20 kg N/ha (i.e. the risk class reported for the majority of Ontario's farmlands). Although Ontario ranked high in terms of nitrogen runoff, 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 and phosphorus (P) by waste treatment plants are 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 $435 per hectare (i.e. range from $132 to $739/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. Using the national average, about 4 million kilograms of excess phosphorus may run off croplands in the Greenbelt. Based on a low-end estimate, the Greenbelt wetlands have the capacity to absorb at least 5.2 million kilograms of phosphorus per year. The average value of wetland treatment services for excess phosphorus is $2,581 per hectare per year (a range of $1,358 to $3,805/ha/year), based on the costs of water treatment to remove excess phosphorus.

The annual total for waste treatment of nitrogen and phosphorus by wetlands in the Greenbelt is an estimated $284 million or $3,017 per hectare (based on a range of values from $1,490 to $4,544/ha/year).

3.2.5 THE VALUE OF HABITAT PROVIDED BY WETLANDS

The majority of Ontario's species at risk are found in southern Ontario where much of the natural areas are fragmented and most of the land is privately owned. The Greenbelt is home to 72 species at risk, and provides habitat for more than one-third of all of Ontario's species at risk (Figure 7). As a result, at least 36 per cent of the province's species at risk are supported by the protection of the Greenbelt. The importance of habitat protection and the provision of connecting corridors for wildlife will become more and more important based on the projected impacts of climate change on ecosystem shifts.

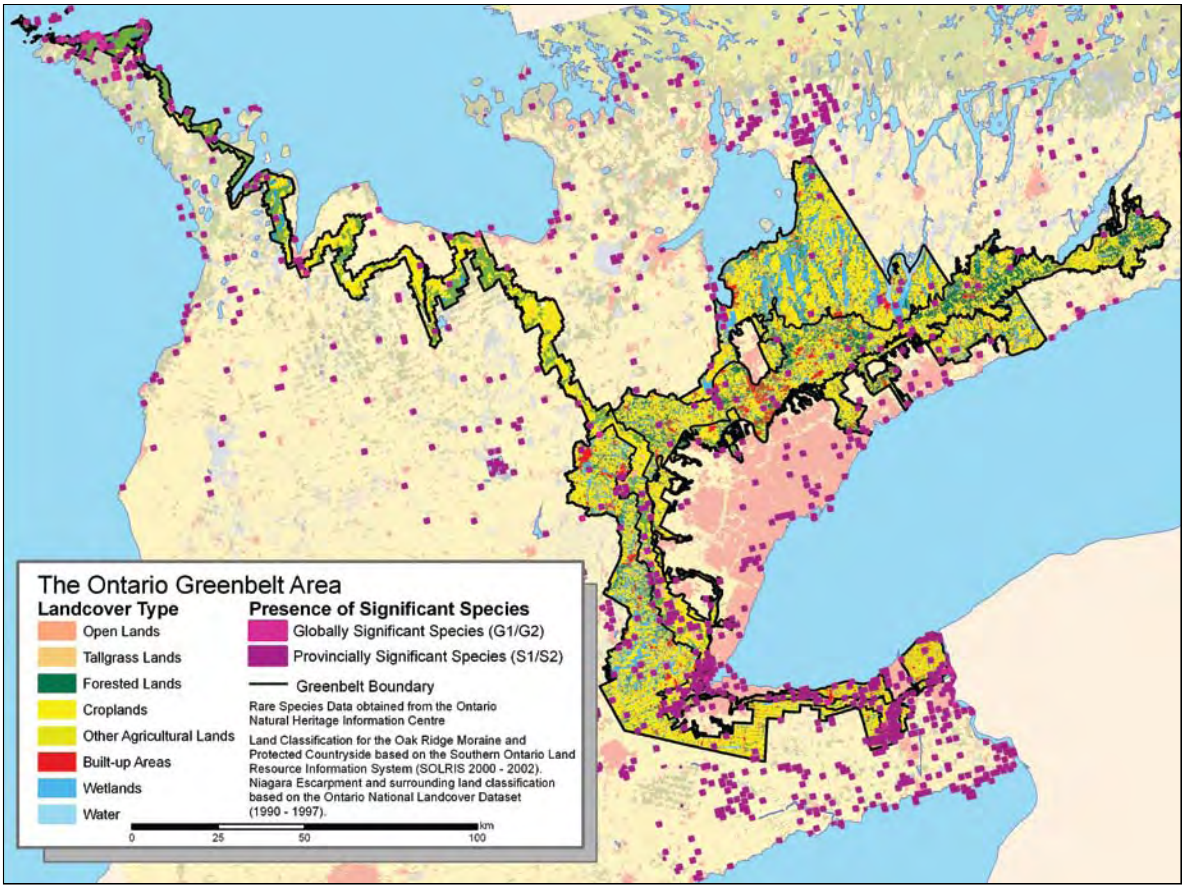


Figure 7: Presence of Rare Species Habitat in the Greenbelt

Wetlands are well known for the important habitat they provide for many species, especially birds, amphibians and reptiles. The annual value for wetlands habitat services is an estimated $548 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.[91] 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. 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.[92]

3.2.6 THE VALUE OF WETLANDS FOR RECREATION

The value of recreation is based on a 1996 national survey that estimates the economic impact of nature-based recreation and the willingness to pay for nature-based activities.[93] Ontario's annual nature-based recreation value from the 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, approximately 9.5 million hectares of land is protected in Ontario, thus the annual recreational value per hectare is an estimated $335.[94] Based on this value, the total annual recreational value for wetlands in the Greenbelt is $31.5 million. We have also used this value for the recreation services for the forest and water cover types in the Greenbelt (also see section 3.1.6).

3.2.7 THE TOTAL ANNUAL NON-MARKET VALUE OF THE GREENBELT'S WETLANDS

The total annual non-market value of the Greenbelt's wetlands is an estimated $1.3 billion; an average $14,153 per hectare (Table 6).

Table 6: Summary Table of Wetland Ecosystem Service Values

ECOSYSTEM SERVICES	OPEN WATER $/HA/YEAR	BOG $/HA/YEAR	MARSH $/HA/YEAR	SWAMPS $/HA/YEAR	FEN $/HA/YEAR	TOTAL $MILLIONS
Climate regulation (carbon stored)	$676.59	$486.09	$539.61	$429.41	$1,360.35	$41.8
Climate regulation (annual carbon uptake)	$13.02	$13.02	$13.02	$13.02	$13.02	$1.2
Flood Control	$4,038.51	$4,038.51	$4,038.51	$4,038.51	$4,038.51	$379.7
Water filtration	$473.98	$473.98	$473.98	$473.98	$473.98	$44.6
Erosion control and sediment retention						n/a
Nutrient cycling						n/a
Waste treatment (removal of excess N and P runoff)	$3,017	$3,017	$3,017	$3,017	$3,017	$283.6
Biological control						n/a
Habitat/Refugia	$5,830.88	$5,830.88	$5,830.88	$5,830.88	$5,830.88	$548.2
Genetic resources						n/a
Recreation & Aesthetics	$335	$335	$335	$335	$335	$31.5
Cultural/Spiritual						n/a
Total per ha $/ha/yr	$14,385	$14,194	$14,248	$14,138	$15,069	
Area (ha)	571	578	10,225	82,459	181	94,014
Total value $M/yr	$8	$8.2	$146	$1,166	$2.7	$1,331

n/a: indicates that information/data was not available

3.3 Beach and Sand Dune Ecosystem Values

Beaches are special places for recreation and relaxation. Many beaches are associated with sand dunes, which interact to provide significant ecological services. Sand dunes are hills of sand covered with long grasses and shrubs. They are nature's shore protection. Beaches and dunes are a dynamic environment, changing constantly as a result of waves and wind. Waves tend to erode the dune during storms and high lake levels. Wind, on the other hand, builds up the dune to form a reserve of sand that acts as a protective buffer against future storm waves.

The area of beaches and sand dunes in the Greenbelt was not reported as part of the SOLRIS land cover data. However, it is useful to take note of the value sand dunes provide. For example, the structural replacement cost for coastal protection along Lake Huron is $2000 per metre.[95] Sauble Beach's three kilometres of beaches and dunes have been valued at $6 million for shore protection alone.[96]

The recreational value of beaches has been calculated for the Great Lakes. The annual value of beaches in the eco-region ranges from $200 to $250 million, according to a 2006 report.[97] If this value is divided by the total Great Lakes shoreline area, an average values per hectare of $125 per year is derived. This is not included in our overall ecosystem service values because of the lack of data on this type of land cover.

3.4 Grassland Ecosystem Values

3.4.1 CARBON VALUES

Grasslands are the natural land cover of approximately a quarter of the earth's surface, however, a large proportion of grasslands have been converted to grazing lands and croplands.[98] Grassland ecosystem services are often overlooked, yet they provide several vital services such as climate regulation, genetic biodiversity, and soil conservation. Grasslands cover 441 hectares of the Greenbelt; only one per cent of the total area.

Grasslands store more carbon than cultivated lands because they provide a complete vegetative cover and plants grow for seven to eight months of the year, instead of the typical three to five months for agricultural crops.[99] When grasslands are ploughed or converted to agricultural lands carbon is rapidly released to the atmosphere. Even when grassland is restored, carbon recovery is slow.[100]

The carbon stored in the Greenbelt grassland soils was estimated at 105 tonnes per hectare based on the results of a Canadian grassland study.[101] Using this estimate, grassland in the Greenbelt store about 43,400 tonnes of carbon, worth an annual value of $438 per hectare.[102]

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.[103] 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.[104] Based on this information, we estimated the value of grassland carbon uptake to be $28.46 per hectare. The additional annual carbon uptake by grasslands in relation to croplands can be estimated at 215 tonnes of carbon per year in the Greenbelt, worth about $12,556 per year.

3.4.2 OTHER GRASSLAND ECOSYSTEM VALUES

Grasslands also provide other vital services such as soil conservation and genetic resources. Soil conservation is important because it prevents soil erosion which can result in lost production, water infiltration, water availability and nutrient availability. In addition, grasslands have provided many domesticated food plants and hold the potential for new sources of plants that have unique genetic features such as resistance to disease.

- The annual value of $12/ha/year for air quality services from grasslands is a global average.[105]
- Based on a regional study on the value of New Jersey's ecosystem services, the annual grassland values include:
    - water regulation ($7/ha/year);
    - erosion control ($50/ha/year);
    - soil formation ($10/ha/year);
    - waste treatment ($146/ha/year);
    - biological control ($40/ha/year); and,
    - recreation and aesthetics ($3/ha/year).
- Pollination services provided by grasslands were estimated at $1,109 per hectare per year based on the value of natural cover in the Greenbelt and an estimated 30 per cent of food production that relies on pollination (see forests pollination services section 3.1.7 for details).

3.4.3 SUMMARY OF GRASSLANDS ECOSYSTEM VALUES

The estimated annual value of the region's grasslands is approximately $714,000, or $1,618 per hectare (Table 7).

Table 7: Summary Table of Grassland Ecosystem Values

ECOSYSTEM SERVICE FUNCTIONS	VALUE PER HECTARE $/HECTARE/YR	TOTAL VALUE $/YR
Total grassland area (ha)	441	
Air Quality	$12	$5,332
Climate regulation (carbon stored)	$213	$94,138
Climate regulation (annual carbon uptake)	$29	$12,611
Water runoff control	$7	$2,923
Erosion control and sediment retention	$50	$22,091
Soil formation	$10	$4,385
Nutrient cycling		n/a
Waste treatment	$146	$64,306
Pollination (agriculture)	$1,109	$489,141
Biological control	$40	$17,538
Habitat/Refugia		n/a
Recreation & Aesthetics	$3	$1,462
Total per year	$1,618	$713,925

n/a: indicates information/data was not available

3.5 Agricultural Lands

Agriculture is vital to the province as a local food source and an economic driver for the province. The Greenbelt protects prime agricultural and specialty cropland from development, and ensures that these lands can continue to provide Ontarians with fresh produce and a secure local food supply. Ontario has the more than half of Canada's best farmland (i.e. most productive (class 1) agricultural lands); however, protection of farmland is important because urban encroachment has resulted in the loss of farmland. For example, between 1996 and 2001, 16 per cent of farmland in the Greater Toronto Area was converted to urban land use.

Many of these lands have been converted to built-up urban areas, urban recreational areas and roads. Based on our spatial analysis, 23,574 hectares, or eight per cent, of the total 283,620 hectares of class 1 soil lands in the Greenbelt region have been converted. Meanwhile, 177,308 hectares, or 13 per cent, of the total 1.34 million hectares of class 1 soil lands have been converted in the municipalities adjacent to the Greenbelt. The percentage conversion of class 1 lands ranges by area. Conversion is highest in the City of Toronto, where 38,433 hectares have been converted.

The Greenbelt protects prime agricultural and specialty cropland from development, and ensures that these lands can continue to provide Ontarians with fresh produce and a secure local food supply.

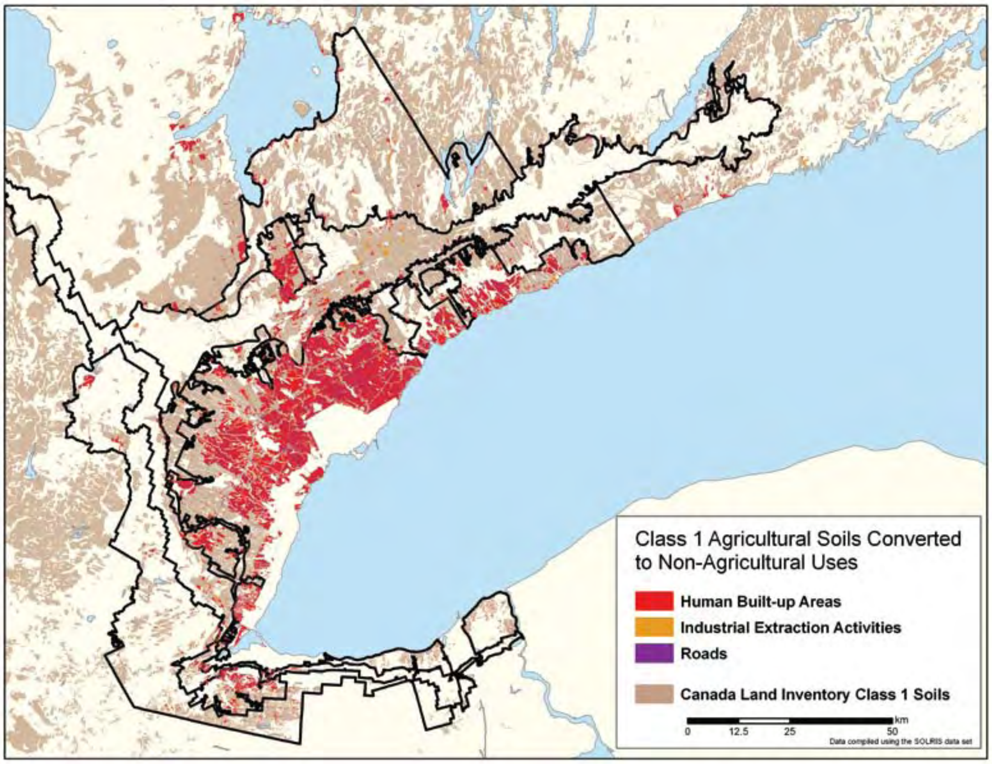


Figure 8: Loss of Class 1 Agricultural Lands in the Greater Toronto Area and Greenbelt

Farmland is the predominant land use in the Greenbelt. Agricultural lands cover approximately 475,500 hectares, or 63 per cent of the Greenbelt (Table 8). Mixed crop (32 per cent of croplands) is the predominant crop cover, followed by idle land, annual crop lands, grazing lands known as perennial crop cover, and hedgerows. Specialty cropland includes vineyards and orchards in the Niagara region (Figure 9). A further 20 per cent of croplands are located in the northern arm of the Niagara Escarpment.

Table 8: Agricultural Lands in the Greenbelt

LAND COVER	LAND COVER TYPE	AREA (HA)	PER CENT OF FARMLAND	PER CENT COVER OF GREENBELT AREA
Agriculture	Mixed Crop	153,705	32%	20%
	Agriculture (NEC)	96,103	20%	13%
	Idle Land	78,889	17%	10%
	Annual Crop	72,731	15%	10%
	Perennial Crop (grazing land)	55,702	12%	7%
	Vineyards	6,137	1.3%	0.8%
	Orchards	5,202	1.1%	0.7%
	Hedge Rows	7,039	1.5%	0.9%
	Total	**475,508**	100%	63%

There are more than 7,000 farms in the Greenbelt, the majority of which are family run.[106] A range of products are grown including fruits (i.e. peaches, pears, plums, cherries, grapes), vegetables, and grain, as well as specialty crops such as Asian vegetables, mushrooms, herbs, horticultural products, and honey. A variety of livestock including sheep, lamb, goat, horses, and deer are also raised in the Greenbelt.

3.5.1 AGRICULTURAL LANDS AS A CARBON BANK

Organic carbon stored in agricultural soils was assessed using spatial analysis of the Canadian Soil Organic Carbon Database.[107] Results show that Greenbelt agricultural soils store 40 million tonnes of carbon. The carbon stored is worth $157 million per year based on the average cost of carbon emissions; an average annual value of $350 per hectare (C$52/tC).[108] The average soil carbon content is 80 tonnes of carbon per hectare, ranging from 71 tonnes to 90 tonnes of carbon per hectare.

3.5.2 CARBON SEQUESTRATION SERVICES BY AGRICULTURAL LANDS

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.[109] 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.[110] Based on

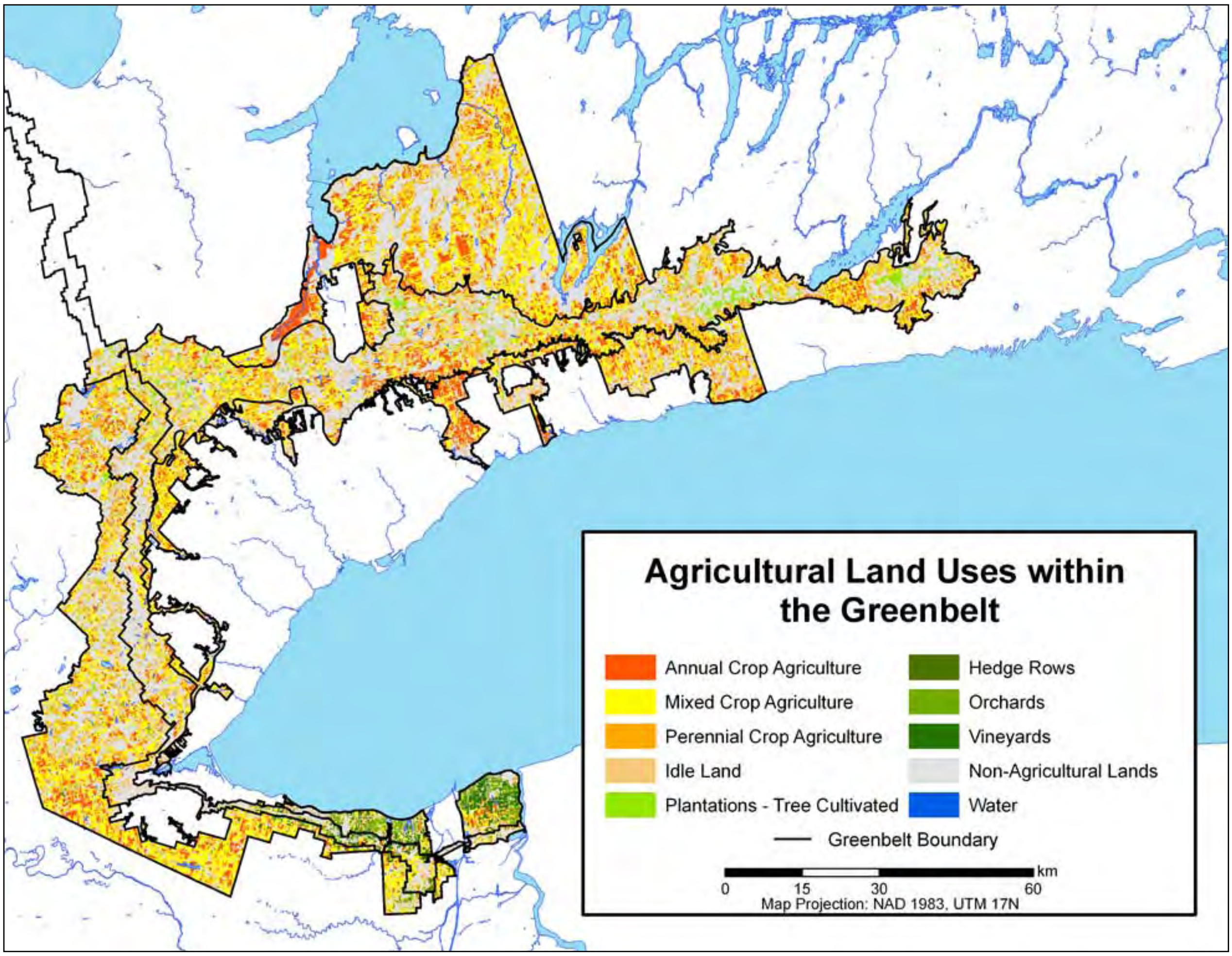


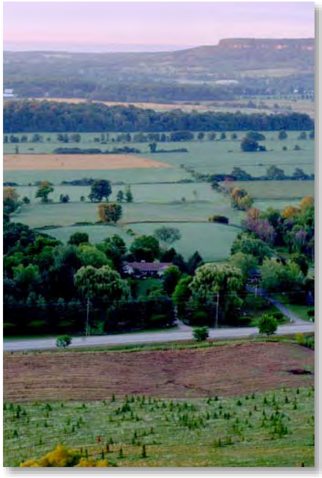
Figure 9: Agricultual Land Use in the Greenbelt

this information, we estimated the value of idle land, orchards and hedgerows to be $29 per hectare.

3.5.3 CULTURAL VALUE OF AGRICULTURAL LANDS

Overall aesthetics is traditionally factored into the cultural value of agricultural lands. This value is reflected today in terms of property values, tourism values, and weekend visits to the countryside and its communities.

A study that surveyed the willingness of residents in Eastern Canada to pay (WTP) for farmland preservation determined the annual value per acre at $97 (1991$).[111] Assuming that at a minimum 10 per cent of the GTAH households place this economic value on farmland preservation, the cultural value of the Greenbelt's farmlands is estimated at $138 per hectare per year.



3.5.4 THE VALUE OF HEDGEROWS (SHELTERBELTS)

Hedgerows and shelterbelts are found around the edges of farm fields. These shelterbelts are beneficial for agriculture and wildlife. They minimize soil erosion and increase soil moisture by reducing the effects of wind. They also provide habitat and nectar resources for pollinators and natural pest control species, as well as habitat and travel corridors for wildlife.[112] Shelterbelts can increase crop yields by up to 35 per cent.[113] The values of hedgerow ecosystem services include:

- Carbon storage values estimated at $328 per hectare per year, based on soil organic carbon data.
- Carbon sequestration services at $29 per hectare.[114]
- The annual value of erosion control ($6 per hectare), and nutrient cycling ($23 per hectare) are benefits attributed to permanent vegetative cover.[115]
- Soil formation is based on the value of soil building by earthworms ($6 per hectare per year).[116]
- Pollination services that are greatly enhanced and supported by hedgerows and idle land. Pollination services are worth $1,109 per hectare per year (see pollination services in forests section 3.1.6).
- The annual value of biological control provided by agricultural land transferred at a value of $40 per hectare.[117]
- The annual cultural value adapted from an Eastern Canada study is an estimated $138 per hectare (see section 3.5.3 above).[118]

3.5.5 THE VALUE OF IDLE FARMLAND

Setting aside farmland as idle land that converts to permanent vegetative cover provides numerous benefits to support farming and environmental quality. The conversion of cropland to permanent vegetative cover provides food, nectar and habitat for pollinators, increases the carbon sequestration, and helps control runoff and absorb wastes. The economic benefits of the Greenbelt's idle farmland include:

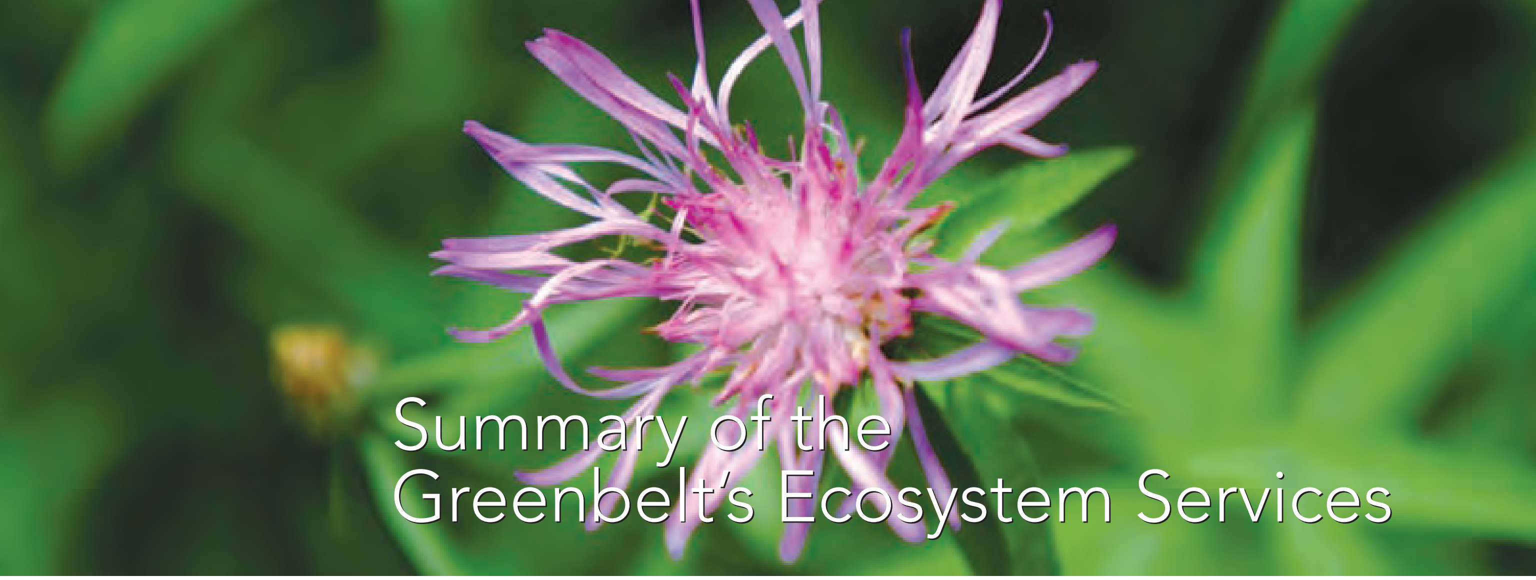
- Annual carbon storage values are $316 per hectare based on data from the Soil Organic Carbon Database.
- Carbon sequestration services are $29 per hectare.[119]
- The annual value of erosion control and sediment retention estimated at $6 per hectare, and soil formation at $6 per hectare. Both values are transferred from the Ontario *Nature Counts* report, which estimates the economic benefits of converting tilled agriculture lands to permanent vegetative cover.[120]
- Pollination services that are greatly enhanced and supported by hedgerows and idle land are worth an annual value of $1,109 per hectare.
- The annual value of biological control provided by agricultural land transferred at a value of $40 per hectare.[121]
- The annual cultural value adapted from an Eastern Canada study is an estimated $138 per hectare (see section 3.5.3 above).[122]

3.5.6 SUMMARY OF AGRICULTURAL ECOSYSTEM SERVICE VALUES

Table 9 provides a summary of the ecosystem services provided by agricultural lands. The total non-market value of the Greenbelt's croplands is estimated at $183 million per year ($477/ha/year). The annual value of idle land is estimated at $132 million, or $1,667 per hectare. The annual value of hedgerows is estimated at $12 million, or $1,678 per hectare. The annual cumulative total value is $329 million per year.

Table 9: The Value of Ecosystem Services provided by the Greenbelt's Farmlands

ECOSYSTEM SERVICES	CROPLAND $/HA/YEAR	IDLE LAND $/HA/YEAR	HEDGEROWS $/HA/YEAR	ORCHARDS $/HA/YEAR	TOTAL $MILLIONS
Climate regulation (stored carbon in soils)	$333	$317	$328	$298	$156.7
Climate regulation (annual carbon uptake)		$29	$29	$29	$2.6
Erosion control and sediment retention		$6	$6	$6	$0.5
Soil formation	$6	$6	$6		$2.8
Nutrient cycling		$24	$24	$24	$2.1
Habitat for Pollination for Crop Production		$1,109	$1,109		$95.3
Biological Control		$40	$40		$3.4
Cultural value	$138	$138	$138	$138	$65.7
Total $/ha/yr	$477	$1,667	$1,678	$494	
Area (ha)	384,378	78,889	7,039	5,202	475,508
Total value $M/yr	$183	$132	$12	$3	$329



Summary of the Greenbelt's Ecosystem Services

The total annual value of the Greenbelt's non-market ecosystem services is an estimated $2.6 billion.

The total annual value of the Greenbelt's non-market ecosystem services is an estimated $2.6 billion, or an average of $3,487 per hectare per year (see Appendix A for a detailed summary of ecosystem service values per hectare by land cover category).

The ecosystem services with the highest values are habitat, flood control, climate regulation, pollination, waste treatment, and control of water runoff (Table 10).

Table 10: Total Value of Greenbelt's Ecosystem Services by Ecosystem Service

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/Spiritual (agriculture)	$65,674,796
Total value ($/year)	$2,651,707,951

The value for each land cover type is provided in Table 11. The highest values per hectare are attributed to wetlands and forests. Wetlands are worth an estimated $1.3 billion per year ($14,153/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, but these areas in southern Ontario have declined considerably since early settlement by Europeans. The total area has decreased from an estimated 23,800 square kilometres (25 per cent of the region) in 1800 to about 9,300 square kilometres (10 per cent of the region) in 1982.123 If we use the average wetland value per hectare, the loss in wetland – 1.5 million hectares – would add up to $21.7 billion. As they become scarcer, their presence and services have become more valuable.

Forests and wetlands have the highest ecosystem values per hectare.

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 $989 million each year.

The Greenbelt's agricultural lands total value is also substantial at an estimated $329 million per year including cropland, idle land, hedgerows, and orchards. Key values include the pollination value of idle land and hedgerows, the storage of carbon in soils, and the cultural value of agricultural lands.

Table 11: Summary of Non-Market Ecosystem Service Values by Land Cover Type for Ontario's 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
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
Other	42	$0	$0
Total	760,420	$3,487	$2,652

4.1 The Distribution of Ecosystem Values

Figure 10 presents the ecosystem service value (per hectare) by watersheds to illustrate the range of value across the Greenbelt. This provides an indication of the relative importance of the contribution of the watershed to the Greenbelt.

The highest values are in the northern part of the Niagara Escarpment near Georgian Bay, and along the top of the northeast section of the Greenbelt south of Lake Simcoe. Annual values range from about $2,000/hectare to greater than $6,000/hectare.

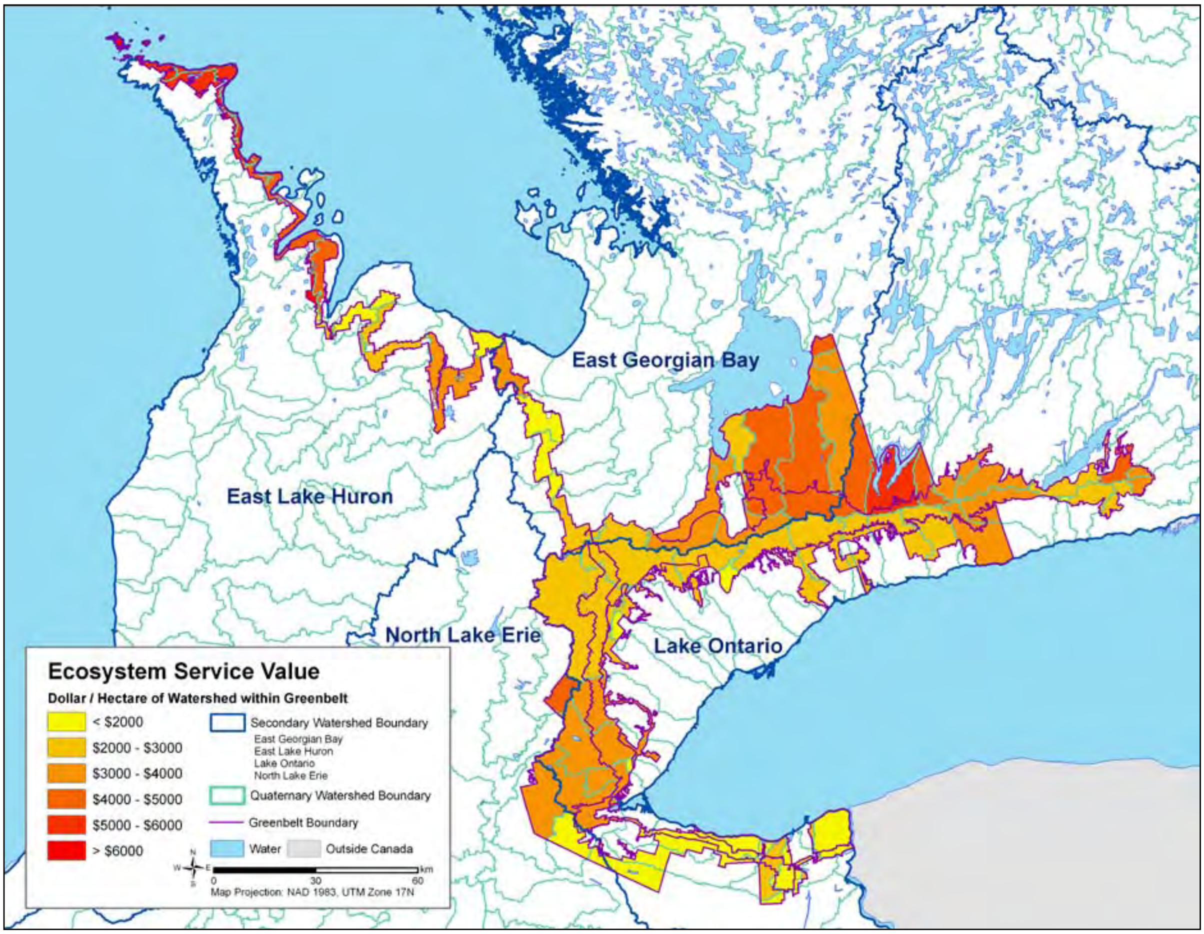


Figure 10: The Distribution of Annual Ecosystem Services per Hectare by Watershed Unit in the Greenbelt

Conclusion

We are all directly dependent on the natural environment for the goods and services that ecosystems provide. These natural benefits include the ability to grow food, breathe air, drink water, experience nature, and support wildlife and their habitat. The Greenbelt's working landscapes provide essential ecosystem services or benefits for the eight million residents across the Greater Golden Horseshoe. Those services are worth at least $2.6 billion each year, or $8 billion since the establishment of the Greenbelt in 2005.

This ecosystem service account confirms the foresight of the province in establishing the Greenbelt three years ago, but also underscores the need to ensure effective implementation of the policies of the Greenbelt Plan. As well, it demonstrates the potential costs of land use change and human impacts in the Greenbelt and surrounding areas.

The importance and value of natural capital must be an essential part of land-use planning and policy decisions (including infrastructure projects) 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 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.

Protection of natural capital and the ecosystem services that it provides will become even more important as the climate changes. The projected impacts of global 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.

Recommendations

> It is important that the province maintain its strong leadership role in the implementation of the Greenbelt Plan.

The Greenbelt Act and Plan provide the framework to protect 1.8 million acres of natural heritage, agricultural lands and water resources in the Greater Golden Horseshoe. Residents living in and around the Greenbelt, as well as visitors to the area, benefit from the goods and services that its ecosystems provide. Those benefits have significant value, underscoring the importance of maintaining the integrity and functioning of the ecosystems that provide them.

Based on the report's findings, the David Suzuki Foundation puts forward the following recommendations to safeguard the natural wealth provided by the Greenbelt:

GROWING THE GREENBELT

1. 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

2. 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 and work collaboratively with municipalities and conservation authorities – all of whom have a key role in conserving and enhancing natural capital.

NATURAL AND HYDROLOGICAL FEATURES CLASSIFICATION

3. 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

4. Municipalities should work with conservation authorities and local communities to enhance the resiliency of ecosystems and the benefits they provide. This includes wetland creation, tree planting, and environmentally sensitive park and trail creation.

STEWARDSHIP FUNDING

5. 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

6. 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 natural capital and its role in providing clean air, clean water, healthy food, and wildlife protection.

Appendix A:

SUMMARY TABLE OF NON-MARKET ECOSYSTEM SERVICES FOR THE GREENBELT BY ECOSYSTEM SERVICE AND LAND COVER TYPE

Table 12: Summary Table of Non-Market Ecosystem Services for the Greenbelt by Ecosystem Service and Land Cover Type

	FOREST	GRASSLANDS	WETLANDS					WATER		AGRICULTURAL LANDS				
ECOSYSTEM SERVICE FUNCTIONS	COOL TEMPERATE		OPEN WATER	BOG	MARSH	SWAMPS	FEN	RIVERS	SAND BARREN	CROPLAND	IDLE LAND	HEDGEROWS	ORCHARDS	TOTAL
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						
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**	**$335**	**$-**	**$477**	**$1,667**	**$1,678**	**$494**	**$3,487.16**
Area (ha)	182,594	441	571	578	10,225	82,459	181	7,821	42	384,378	78,889	7,039	5,202	760,420
Total value $M/yr	**$989**	**$0.71**	**$8.2**	**$8.2**	**$146**	**$1,166**	**$2.7**	**$2.6**	**$-**	**$183**	**$132**	**$11.8**	**$2.6**	**$2,652**

Appendix B: Methodology

PURPOSE OF PROJECT

To profile the importance of the natural capital and ecosystem services provided by Ontario's Greenbelt through an assessment of the benefits provided to communities in the Golden Horseshoe. This report provides an account of the land cover types and the regions' ecosystems, and quantifies the non-market values provided by the Greenbelt's ecosystems.

LAND COVER ANALYSIS

The types of ecosystems 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.

IDENTIFICATION OF ECOSYSTEM FUNCTION AND SERVICES

Ecosystem functions are the processes (physical, chemical, and biological) or attributes that maintain ecosystems and the species that live within them. Ecosystem goods and services are defined as the benefits human populations derive from ecosystems. In other words, these goods and services rely on the capacity of natural processes and systems to provide for human and wildlife needs.[124] 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).[125] The following table provides a list of ecosystem function, processes, and the corresponding ecosystem services (Table 13).

Table 13: 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

Table 13: Continued

FUNCTIONS	ECOSYSTEM PROCESSES OR COMPONENTS	ECOSYSTEM SERVICES
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 re-sources	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 develop-ment: scenery, cultural motivation, environ-mental 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.

Ecosystems, such as wetlands and forests, can be characterized by these processes or functions. Using the ecosystem classifications by ecosystem function developed from a number of published sources,[126] the potential ecosystem services for each land cover type were identified. These are outlined in the following table (Table 14).

Table 14: Ecosystem Services from Different Land Cover and Land Use

ECOSYSTEM SERVICES	FORESTS	GRASSLANDS	RIVERS	WETLAND	CULTIVATED	URBAN PARKS
Fresh water	●		●	●		
Air quality	●					●
Erosion control	●	●		●		
Global climate regulation	●			●		
Local climate regulation	●	●				●
Storm protection				●		
Pest control	●	●			●	
Pollution control	●		●		●	
Waste processing				●		
Flood regulation	●		●	●		
Sediment retention	●	●	●	●		
Disease regulation			●			
Nutrient cycling	●	●	●		●	
Medicines	●					
Recreation/						
ecotourism	●	●	●	●		●
Aesthetic	●	●	●		●	
Spiritual	●	●	●			
Cultural/heritage	●	●	●	●	●	●
Education		●	●	●	●	●

NON-MARKET ECOSYSTEM VALUATION

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 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 most do not have a market to establish a price.

There are several techniques that have been developed to determine economic values for non-market ecosystem services (Table 15). 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. This report uses avoided cost and replacement cost for valuation, as well as contingent valuations or willingness-to-pay studies for cultural values. Some of these values were derived using direct analysis and some values were adapted from other studies known as value transfer. All ecosystem service values are reported in Canadian dollars (2005).

Table 15: Non-Market Ecosystem Valuation Techniques[127]

Avoided Cost (AC): Ecosystem services allow society to avoid costs that would have been incurred in the absence of those services. For example, flood control provided by a barrier island reduces property damage along the coast.
Replacement Cost (RC): Services could be replaced with human-made systems. For example, nutrient cycling waste treatment can be replaced with costly treatment systems.
Net Factor Income (NFI): Services provide for the enhancement of incomes. For example, water-quality improvements increase commercial fisheries catches and incomes from the fishery.
Travel Cost (TC): Service demand may require travel, 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 (HP): Service demand may be reflected in the prices people will pay for associated goods. This method is often used to estimate property values. For example, housing prices along the coastline tend to exceed the prices of inland homes.
Contingent Valuation (CV): Service demand may be elicited by posing hypothetical scenarios in surveys that involve some valuation of land-use alternatives. This method is often used for less tangible services like wildlife habitat or biodiversity. For example, people would be willing to pay for increased preservation of beaches and shoreline.

ECOSYSTEM BENEFIT TRANSFER APPROACH

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.[128]

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 not only many single-service and ecosystem-level studies, but average values from meta-analysis of multiple studies.

ANALYSIS

- CITYgreen is a GIS application for land-use planning and policy-making.[129] It conducts complex statistical analyses of ecosystem services, and calculates dollar benefits based on your specific site conditions. 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's tree cover, and
  - 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 of the forest water filtration services was calculated as the replacement cost of the current condition of the Greenbelt's watersheds. (i.e. average per cent forest cover). The replacement of the forest cover's water treatment costs was calculated using the City of Toronto's current cost of water treatment.

- Carbon stored in the Greenbelt's forests was calculated using our land cover analysis and forest ecosystem carbon content estimates from Canada's Forest Carbon Budget[130]
- Soil organic carbon data from the Soil Organic Carbon Database of Canada was used to assess the carbon stored in the soils of the Greenbelt's wetlands (i.e. by wetland type including open water, bog, swamp, fen, and marsh wetlands), and agricultural soils[131]
- The capacity for waste treatment of excess nitrogen and phosphorus by wetlands was estimated based on averages from published studies, and the amount of excess nutrients were estimated from agricultural studies.

LIMITATIONS OF CURRENT ECOSYSTEM SERVICE VALUATION RESEARCH

Limitations in conducting ecosystem service valuation research 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. The results presented here are a first approximation of the economic value of the ecosystem services provided by nature in the Greenbelt.

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, we are confident that the estimates are meaningful. This report is intended to be a building block in the process of natural capital accounting and ecosystem service valuation and monitoring.

This estimated values provided are likely a conservative estimate, 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. The valuations of ecosystem services, however, provide an opportunity to rigorously assess the current benefits of the Greenbelt and the potential costs of human impact.

Appendix C: 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 two 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. metre: $57.00
Additional Storage volume needed: 17,353,483 cu. meters

PERCENT CHANGE IN CONTAMINANT LOADINGS

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. Using values from the U.S. Environmental Protection Agency (EPA) and Purdue University's L-thia spreadsheet water quality model, American Forests developed the CITYgreen water quality model. This model estimates the change in the concentration of the pollutants in runoff during a typical storm event given the change in the land cover. This model estimates the Event Mean Concentrations of Nitrogen, Phosphorus, Suspended Solids, Zinc, Lead, Copper, Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD). Pollutant values are shown as a percentage of change when the landcover is altered. No valuation is provided for these benefits.

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 U.S. 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 annually in British 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.

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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 rates. 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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Nearly a quarter of Canada's population lives in Southern Ontario's Golden Horseshoe. By the year 2031, the population is projected to increase by another 3.7 million. As a result, unprecedented pressure will be placed on the region.

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This ground-breaking report quantifies the value of the ecosystem services provided by the Greenbelt, revealing the annual value of the region's non-market services provided by nature at billions of dollars. These services include water filtration, flood control, climate stabilization (i.e. carbon storage), waste treatment, wildlife habitat, and recreation.

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