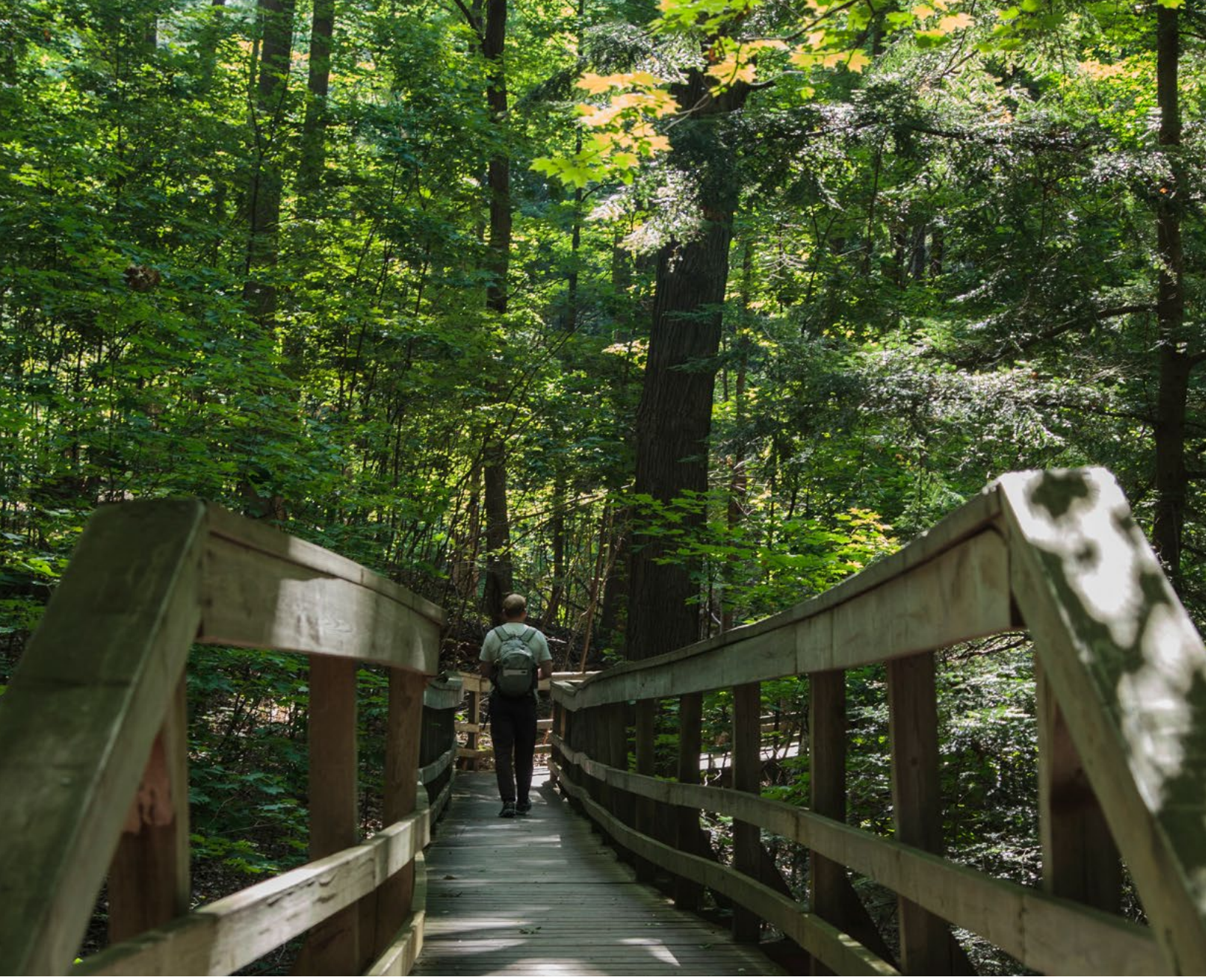

Ontario's Good Fortune: Appreciating the Greenbelt's Natural Capital

Prepared for the Friends of the Greenbelt Foundation
by Green Analytics

Possibility grows here.

Twenty in a Series
Friends of the Greenbelt Foundation Occasional Papers
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The Friends of the Greenbelt Foundation is committed to promoting awareness and education about Ontario's Greenbelt. To this end we occasionally publish research and general interest papers that explore our three program areas: viable agriculture and viticulture; vibrant rural communities; and, a restored and protected natural environment.

Valuing Natural Capital in Ontario's Greenbelt. Prepared for the Friends of the Greenbelt Foundation by Jeff Wilson, Amy Taylor and Mike Patriquin of Green Analytics, and Eric Saczuk, Ph.D. of Space Hog Graphics, with contributions from Michelle Brownless and Scott McFatridge of the Smart Prosperity Institute.

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All photographs are courtesy of the Friends of the Greenbelt Foundation.

Possibility grows here.

After publishing this report in October 2016 we noticed an unfortunate copy and paste error that resulted in the hiking, climbing and horseback riding value being allocated to bird watching, and the bird watching value being allocated to hiking, climbing and horseback riding. All impacted tables have been updated in this version.

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18 - Greenbelt Farmers: Sowing the Seeds of Success
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Executive Summary

At nearly 800,000 hectares (2 million acres), Ontario's Greenbelt stretches from Niagara to Northumberland protecting vital agricultural land and greenspace in the Greater Golden Horseshoe. The Greenbelt is home to a wealth of important ecological systems and some of the Province's most productive agricultural land. This natural capital sustains ecological and human health in the region and the Greenbelt is an important agricultural and recreational resource.

Implemented in 2005, the *Greenbelt Plan* protects this vital natural capital by preventing new urban development in greenfield areas within its boundaries. Residents in the Greater Golden Horseshoe gain significant benefits from the natural and environmental features protected by the Greenbelt. From the clean air and water that sustains human life to the natural beauty of the landscape that provides recreational opportunities, the Greenbelt is uniquely positioned to provide and preserve a high quality rural and agricultural landscape for the benefit of millions of Ontarians.

Green Analytics and Smart Prosperity Institute were commissioned by the Friends of the Greenbelt Foundation to provide an updated estimate of the value of natural capital in Ontario's Greenbelt, building on an assessment that was first carried out in 2008. The current report has three main purposes:

1. To estimate the value derived from the natural capital of the Greenbelt.
2. To establish a baseline natural capital accounting framework that can be maintained and built upon over time to support decision making and advocacy work related to the Greenbelt.
3. To present a natural capital accounting framework that demonstrates to decision makers how to identify and measure the benefits derived from natural capital.

Approach

Ecosystem service assessment and natural capital valuation is a field of study that is changing and advancing as new tools and approaches are developed. This report draws on the recently developed *National Ecosystem Services Classification System* (NESCS), to conceptualize and articulate a series of ecosystem service accounts for the Greenbelt. The Greenbelt accounts were separated into three environment categories – aquatic, terrestrial and atmospheric. In total, 39 aquatic accounts, 63 terrestrial accounts, and one atmospheric account were identified, of which 26, 38, and 1 respectively, were valued. The general process used to quantify each account entailed:

1. Assessing beneficiaries (end users of the ecosystem service flows) by considering the following questions:
   - Who are the beneficiaries?
   - Where they are located?
   - How many beneficiaries are there?

2. Determining the quantity of services being utilized by the beneficiaries (e.g. days of recreation, reduction in air pollution, volume of water used). The estimated quantity of services used was made as spatially explicit as possible.
3. Determining the value of final ecosystem service flows. For the purpose of this assessment, these values were determined using value transfer techniques[1] guided by the following rules:
   - Values were transferred from Ontario-based research first, Canadian-based research second, then other jurisdictions third.
   - Value function transfer methods were used over unit value transfers as research shows that function transfers result in a much lower transfer error.[2]

An Emphasis on Final Ecosystem Services and Beneficiaries

Natural capital valuation tracks, values, and measures the contribution of natural assets to the wellbeing of a region. Thus, it is important that the valuation is based on a systematic approach that focuses on final (or end) benefits to beneficiaries.

> This assessment provides an updated account of natural capital in the Greenbelt. It is based on the latest conceptual thinking around natural capital valuation, making use of the most up to date sources of data and the best possible valuation tools.

Recent approaches to natural capital valuation use the concept of **final ecosystem services** (as opposed to intermediate ecosystem services) as the basis for valuation. *Final ecosystem services* are the components of nature, directly enjoyed, consumed, or used to yield human wellbeing.[3] *Intermediate ecosystem* services are the necessary supporting conditions, processes and functions that create final ecosystem services. For instance, the regulation of water quality from surrounding forests and wetlands, nutrient cycling, and biodiversity are all intermediate services that produce final ecosystem services of clean-water provision, fish populations, and river valley landscapes. These final services produce recreational angling benefits that are the measurable improvements to human wellbeing. It is important to note that despite the fact that intermediary services are not specifically quantified using this approach, they are still fundamental to the system's overall value.

Comparison with the 2008 Assessment

The 2008 assessment of the Greenbelt carried out by the David Suzuki Foundation used an approach that did not explicitly focus on final ecosystem services. As a result, in many cases the results of the 2008 study and the current study are not directly comparable.

The 2008 study demonstrated the value of the environment's contribution to human wellbeing and the important contribution of intermediary services. The current study takes the next steps toward establishing a consistent process for natural capital accounting at a regional level by applying the latest assessment tools now considered the industry standard in assessing natural capital. By doing so, this report provides a case study and template for municipalities and other land resource managers to establish accounts to better understand and measure the contribution of natural assets to a region. A detailed comparison of the two studies is provided in the Sections 3 and 4.

---

[1] Value transfer is the use of research results from a pre-existing primary valuation study to predict the value of unstudied sites or areas. For a detailed background on value transfer see Robert J. Johnston, John Rolfe, Randall S. Rosenberger & Roy Brouwer, Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners, (London: Springer, 2015).

[2] Ibid.

[3] James Boyd & Spencer Banzhaf, "What are Ecosystem Services? The Need for Standardized Environmental Accounting Units," Ecological Economics, Vol. 63 No. 2 (2007), p.616-626.

Estimated Value of the Greenbelt's Natural Capital

Overall, the Greenbelt accounts were valued at $3.2 B per year. The table below provides a summary of the values for the three environmental categories used in this assessment. The results show that the terrestrial values account for 65% of the total value.

> "Overall, the Greenbelt accounts were valued at $3.2 B per year.

Table 1. Summary of the Value of Ecosystem Services in the Greenbelt

Use	Total Annual Value ($ Million)
Aquatic Use	
Non-motorized water and beach	162.30
Angling	179.50
Waterfowl hunting	41.40
Subtotal Recreation/Tourism	**383.20**
Subtotal Protection of Human Property	**224.35**
Subtotal Existence, Bequest and Aesthetics	**124.15**
Crop irrigation	7.63
Livestock	1.06
Water supply (households)	358.55
Subtotal Extractive Use	**367.24**
Total Aquatic Use	**1,098.94**
Terrestrial Use	
Hiking, climbing and horseback riding	872.50
Hunting or trapping	35.60
Bird watching	205.00
Cycling and mountain biking	236.30
ATV and snowmobiling	46.70
Cross-country skiing and snowshoeing	326.10
Subtotal Recreation/Tourism	**1,722.20**
Subtotal Plant Cultivation/Pollination	**48.06**
Subtotal Existence, Bequest and Aesthetics	**301.03**
Non-timber forest products	1.03
Maple products	7.26
Livestock grazing	0.89
Subtotal Extractive Use	**9.18**
Total Terrestrial Use	**2,080.47**
Atmospheric Use	
Clean air	18.41
Total Atmospheric Use	**18.41**
TOTAL VALUATION (ALL USES)	**3,197.82**

* Note: Carbon sequestration values are not included in this table since they are considered intermediary services.

A number of key findings are worth highlighting.

The ecological riches of the Greenbelt create natural and rural settings that provide significant recreational value to Ontarians. Recreation in the Greenbelt accounts for two thirds of the value of ecosystem services generating a total of $2.1 B annually. This recreational value is dependent upon people choosing to recreate in the Greenbelt and hence spend their time and money there. The Greenbelt's natural beauty is in part provided by a wide range of intermediate ecosystem services that in turn enhance the recreational offerings of the Greenbelt and increase its value. This highlights the need to maintain the ecological integrity of the Greenbelt so that it can continue to provide premium recreational opportunities to a large portion of Ontario's population.

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The Greenbelt's natural capital protects private and public property by reducing flood risk. Using the results of a custom meta-analysis, the value of property protection was estimated to be $224 M per year. This was the total estimated for over 15,000 provincially significant wetlands throughout the Greenbelt, whose individual wetland values ranged from $3,000 to over $5.5 M per year. The average wetland within the Greenbelt provides over $1 M per year in protection to human property.

> The value of property protection was estimated to be $224 M per year, whose individual wetland values ranged from $3,000 to over $5.5 M per year. The average wetland within the Greenbelt provides over $1 M per year in protection to human property.

The Greenbelt's natural capital reduces health care costs by removing air pollution. The health benefit provided by air quality improvements resulting from forest cover within the Greenbelt was estimated to be $18 M per year. The value varies regionally across the Greenbelt depending on the amount of tree cover in the area, the ability of those trees to remove pollutants, the concentration of pollutants in the area, and the population density of the people linked to the surrounding area.

The Greenbelt's natural capital provides valuable intermediary services such as a carbon storage and sequestration. While this report focuses on final ecosystem services, it is important to recognize the significant climate change mitigation value the Greenbelt provides in carbon storage and sequestration. Since people generally do not directly or indirectly engage with carbon storage or sequestration, such values are considered intermediary services. The total value of carbon stored in the Greenbelt's forests, wetlands, and agriculture was estimated to be $11.17 B. Annual sequestration from forests, wetlands, and agriculture is currently adding to this value at a rate of $51.94 M per year.

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Implications for Decision Makers

The natural capital accounting framework employed in this study is useful for decision makers concerned with policy, planning and land use decisions. Specifically, for a defined geographic area, the framework can be used to:

- Educate policy makers and the public on the economic importance of protecting and enhancing natural capital and green infrastructure.

- Establish the baseline conditions for a defined geographic area from which alternative policy, planning and land use changes can be assessed.

- Inform policy decisions related to resource developments and conservation:
  - Identify the natural capital accounts of high value to beneficiaries and that perhaps should be protected from aggregate extraction or highway infrastructure if potential conflicts arise.
  - Identify the natural capital accounts of low value to beneficiaries that may deliver multiple gains through investment in restoration or enhancement. For example, forest restoration that would serve conservation goals while improving air quality and providing additional recreational opportunities.

- Incorporate the value derived from natural capital into cost-benefit analysis to inform and help prioritize investment in the protection, conservation, restoration or enhancement of natural capital.

- Assign value to the natural capital that can be integrated with traditional economic and/or economic accounting frameworks (e.g. gross domestic product) to consider the magnitude of, or implications to, the value derived from natural capital on a level playing field with market-based goods and services.

- Provide an additional tool to assess the success of conservation, preservation, protection and restoration initiatives on the value derived from natural capital.

Natural capital accounting can inform cost-benefit analysis. For example, it can help identify priority wetlands to invest in to support the protection of human property from damage due to flooding. The cost of restoring any particular wetland can thus be compared with the value derived by beneficiaries in the form of reduced risk of damage from flooding. As the risk of flood increases over time due to the impacts of climate change, assessing the value of natural capital using the accounting framework presented in this study can help justify investments in climate adaptation and prioritize wetlands that will result in the greatest benefits.

Understanding the value of ecosystem services, who benefits from them, and how values change depending on how the landscape is managed, is important information for land use planners and decision makers responsible for managing natural assets, as well as communities benefiting from those services.

This report continues to build a better understanding of the value of the Greenbelt's natural capital, but it's not the end of the process. The study identified a total of 100 accounts and found data to value 65 of them. Natural systems are also in constant flux as is their relationship with human activity. The framework developed in this study can be updated with new data, be used to capture changes over time, and inform decisions about land use management and policy.

It is worth noting that individual relationships to the land are complex and also evolve, and for some people the Greenbelt's natural capital will forever be priceless.

1 Introduction

At nearly 800,000 hectares (2 million acres), Ontario's Greenbelt stretches from Niagara to Northumberland protecting vital agricultural land and greenspace in the Greater Golden Horseshoe. The Greenbelt is home to a wealth of important ecological systems and some of the Province's most productive agricultural land. This natural capital sustains ecological and human health in the region and the Greenbelt is an important agricultural and recreational resource.

Implemented in 2005, the Greenbelt Plan protects this vital natural capital by preventing new urban development in greenfield areas within its boundaries. Residents in the Greater Golden Horseshoe gain significant benefits from the natural and environmental features protected by the Greenbelt. From the clean air and water that sustains human life to the natural beauty of the landscape that provides recreational opportunities, the Greenbelt is uniquely positioned to provide and preserve a high quality rural and agricultural landscape for the benefit of millions of Ontarians.

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1. To estimate the value derived from the natural capital of the Greenbelt
2. To establish a baseline natural capital accounting framework that can be maintained and built upon over time to support decision making and advocacy work related to the Greenbelt.
3. To present an advanced natural capital accounting framework that demonstrates to decision makers how to identify and measure the benefits derived from natural capital.

This report contains the results of the assessment and valuation of the natural capital in the Greenbelt. It is organized as follows:

- Following this *Introduction*, the *Study Area* chapter describes the Greenbelt in terms of its size, land cover and population.
- The *Recent Advances in Natural Capital Assessments* chapter contains details on the recent developments in the field of natural capital assessment and valuation addressing the degree to which those advances are reflected in this evaluation of the Greenbelt.
- The *Approach and Conceptual Framework* chapter describes the methods employed to conduct the natural capital assessment and valuation of the Greenbelt, as well as the conceptual underpinnings of that approach as they relate to recent advances in this field of study.
- Chapters 5, 6 and 7 contain the results of the natural capital assessment and valuation for the accounts of relevance to the Greenbelt, namely *The Aquatic Accounts, The Terrestrial Accounts* and *The Atmospheric Accounts*, respectively.
- The *Carbon Storage and Sequestration* chapter presents the results of an assessment and valuation of the capacity of the Greenbelt to store and sequester carbon along with estimates of the monetary value of those services.

- Chapter 9 – *Summary of Greenbelt Accounts* – presents the results of the natural capital valuation of the Greenbelt.
- The *Conclusion and Next Steps* chapter contains concluding remarks regarding the findings of the study and identifies research and analytical approaches that could improve and build on the assessment in the future.

A Primer on Natural Capital Terminology

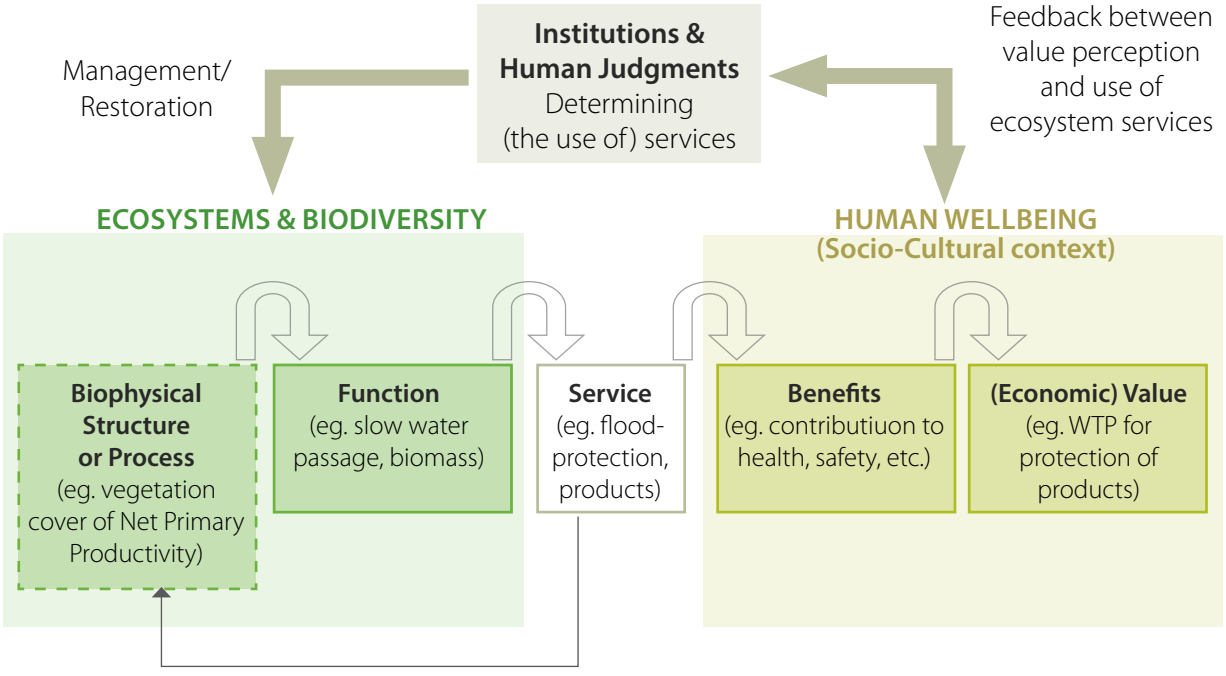
Natural capital refers to a region's stock of natural "assets," such as water, forests, wetlands, air, or soil. Just like other forms of capital, these stocks produce a flow of goods and services over time. For instance, a wetland purifies water, providing a flow of clean water to people downstream.

The flow of goods and services is often referred to as ***ecosystem services***, which are typically defined as the benefits people obtain from nature. A ***benefit*** is the actual improvement in human wellbeing provided by the flow of ecosystem services (e.g. cleaner drinking water).

Beneficiaries are a specific group of people who benefit from the flow of ecosystem services (e.g. those people who live downstream of the wetland and as a result benefit from access to the cleaner drinking water).

The diagram below illustrates the relationship between the services provided by ecosystems and how they can be valued by looking at the benefits they provide in the context of human wellbeing.

The pathway from ecosystem structure and processes to human wellbeing



Adapted from TEEB (2010), The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan, London and Washington.

Study Area

2

Ontario's Greenbelt is comprised of nearly 800,000 hectares (2 million acres) of protected land that wraps around the highly populated Greater Golden Horseshoe area in southern Ontario.[4] The *Greenbelt Plan* was established in 2005 to protect prime farmland and environmentally sensitive areas from urban development and sprawl. The aquatic and terrestrial spaces include wetlands, watersheds, farmlands, and forests that support ecological, cultural, recreational, and economic systems. Table 2 contains different land covers that provide natural capital value as well as the total developed built capital in the area.

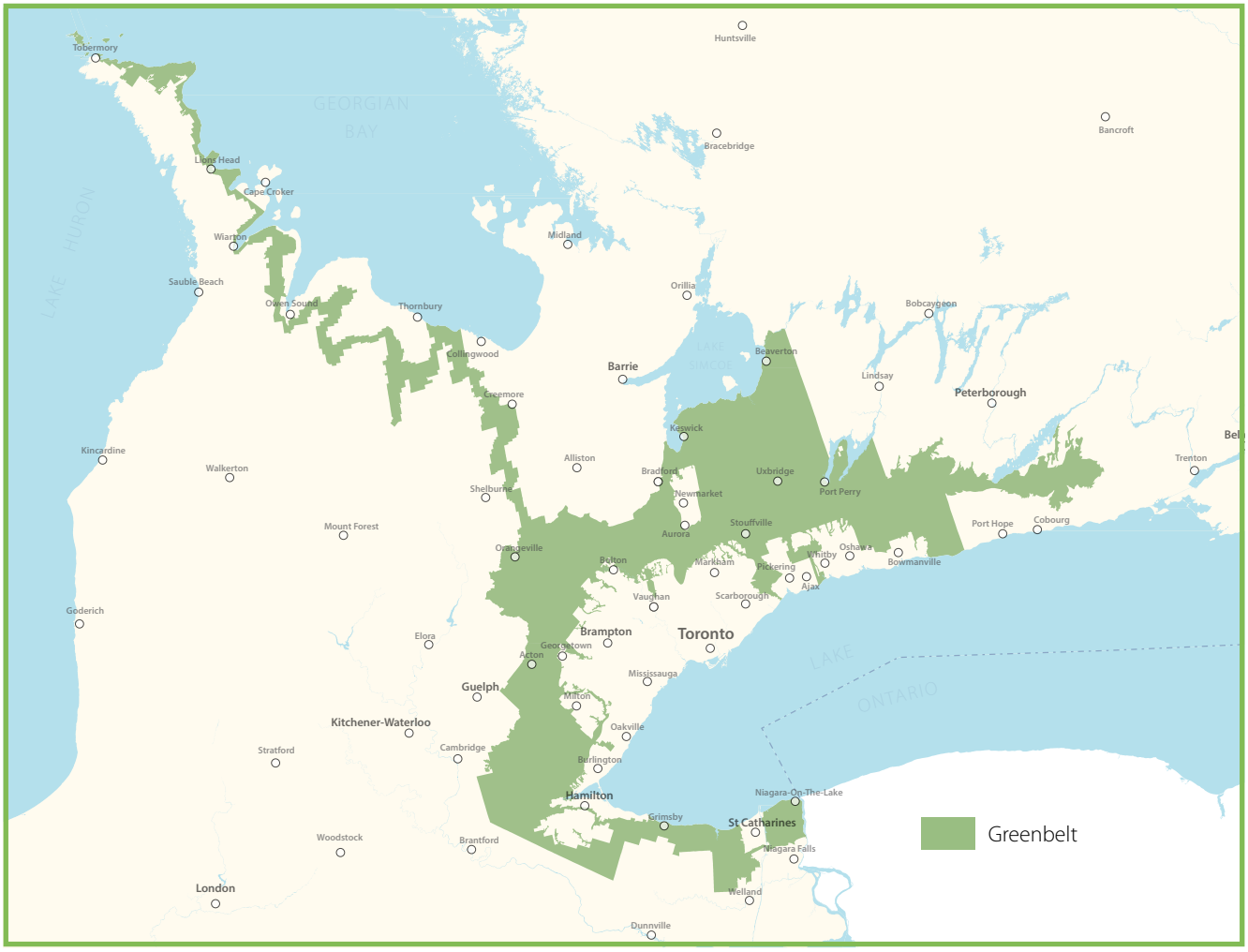


Figure 1: Ontario's Greenbelt

[4] "Greenbelt," Friends of the Greenbelt Foundation, accessed October 4, 2016, http://www.greenbelt.ca/about_the_greenbelt.

Table 2: Land Cover Breakdown for Greenbelt

Type of Capital	Condensed Land Cover Type[5]	Area (ha)[6]
Natural Capital	Agriculture	429,765
	Forest	182,674
	Wetland	100,063
	Water	8,597
	Hedge Row	7,826
	Alvar	212
	Cliff and Talus	144
	Grassland	79
	Beach	4
Built Capital	Developed	66,036
Total		**795,400**

As the table demonstrates, agricultural land is the predominant land cover type in the Greenbelt, followed by forested land cover. Appendix 2 contains detailed figures of the spatial distribution of natural capital resources across the Greenbelt. Table 3 provides a breakdown of the area dedicated to specific agricultural crops.[7]

[5] Land covers categories are based on detailed land cover mapping provided in Ontario Ministry of Natural Resources and Forestry, "Southern Ontario Land Resource Information System (SOLRIS), "Version 2.0: Data Specifications, 2015, https://www.sse.gov.on.ca/sites/MNR-PublicDocs/EN/CMID/SOLRIS%20v2.0%20-%20Data%20Specifications%20Version.pdf. For a summary of how these areas were calculated from the detailed SLORIS data, see Appendix 1.

[6] Area estimates differ slightly from those of the pure SOLRIS 2.0 data as a result of merging the AAFC annual crop inventory data with the SORLIS land cover. The total difference in area estimates is 0.1%.

[7] Agricultural crop data is based on AAFC annual crop inventory data, which was utilized to add more detailed agricultural resolution to the SORLIS land cover data. Any area defined as undifferentiated or tilled within the SOLRIS data was allocated the crop type from the AAFC dataset. There are a few items worth noting if comparing these numbers to those of a recent Friends of the Greenbelt publication called Agriculture by the Numbers, which examined 2011 census results based on custom data produced by Statistics Canada for the Greenbelt specific geography. The census data reports total area farmed to be 856,424 acres (or about 346,600 ha), which is nearly identical to the above estimates of total area farmed if the unspecified area is assumed not farmed (429,765 less 83,670 = 346,096 ha). The AAFC annual crop inventory seems to under represent field crops and over represent pasture and forage as compared to the 2011 census data. However, the AAFC is based on the 2014 growing season, so these differences maybe partially the result of changes that have occurred since 2011. It is also possible that the AAFC data contains errors in the crop type allocation, which has a reported accuracy of about 80% for Ontario based on field verification tests.

Table 3: Distribution of Agricultural Land by Crop Type

Crop Type	Area (ha)
Pasture/forage	181,808
Soybeans	70,879
Corn	56,149
Wheat	19,032
Vineyards	6,292
Orchards	2,556
Oats	1,286
Barley	1,284
Canola	1,069
Fallow	820
Nursery	726
Potatoes	652
Sod	625
Bean	122
Rye	105
Ginseng	74
Triticale	66
Hops	57
Flaxseed	31
Berries	25
Peas	24
Buckwheat	13
Other	2,400
Unspecified*	83,670
Total	**429,765**

* Unspecified areas are those that were both undifferentiated in SOLRIS and unknown within the AAFC annual crop inventory data. This is a limitation of the existing data where the specification of this area is unknown. This could be capturing urban brownfields, hydro and transportation right-of-ways, cloud cover that prevented the remote sensing process to obtain an accurate result, or areas identified as too wet for seeding.

The Greenbelt is particularly valuable from a natural capital perspective due to its proximity to a large portion of Ontario's population. The spatial relationship between the location of natural capital assets relative to those who benefit is extremely important. The location of people relative to natural capital can influence values in two key ways:

1. More people in close proximity to natural capital generally means a greater number of people benefit from the same quantity or quality of a service. Conversely, fewer people in close proximity to natural capital means less benefits are realized. This does not mean such areas are not valuable, simply that the *potential* value is not currently being *captured* by beneficiaries.

2. Some ecosystem services are highly directional, which means benefits are only realized when people are located where the benefits flow. For instance, flood risk reduction benefits provided by wetlands and riparian areas can only accrue to people who live downstream of the natural capital and only in the flood-prone areas that are being protected by the water storage capacity of the upstream landscape.

Given the location of the Greenbelt, there are 9.2 million people that potentially benefit from the flow of ecosystem services from its natural landscape. As is shown in the table below, 1.7 million people reside within the Greenbelt (or 1.4 million people aged 18 and older). If the area within 20 km of the Greenbelt is factored in as well, the population grows to 9.2 million people (or 7.4 million aged 18 and older), accounting for roughly one third of Canada's entire population.[8] Figure 2 maps the population density of all census subdivisions that overlap with the Greenbelt boundaries.

Table 4: Population and Household Figures for the Greenbelt and Ontario

	Total Population	Population Aged 18 and Older	Number of Households
Greenbelt	1,721,026	1,376,820	414,734
Greenbelt with a 20 km Buffer	9,237,433	7,389,946	3,007,490

The Southern Ontario Land Resource Inventory System (SOLRIS) Version 2.0 data was used to examine the shifts that have occurred in the land cover of the Greenbelt in recent years, specifically between 2000 and 2011.[9] The analysis only captures verified land cover changes (all changes due to data or modelling errors have been excluded). Table 5 presents the changes in land cover in the Greenbelt. The most substantive changes resulted in a loss of agriculture land. Between 2000 and 2011, a total of 3,301 hectares of land was converted from agricultural uses, to primarily impervious built up areas (e.g. buildings and roads). Other notable shifts, albeit of a much smaller magnitude, include shifts from wetlands and woodlands to agriculture and shifts from wetlands to extraction (i.e. aggregates). Note that while these shifts constitute the majority of the changes in land cover, even when taken together, the land cover that changed between 2000 and 2011 was a very small proportion (0.6%) of the total land cover of the Greenbelt.

“ Between 2000 and 2011, a total of 3,301 hectares of land was converted from agricultural uses, primarily to impervious built-up areas (e.g. buildings and roads).

[8] The estimates for the population aged 18 and over are derived by applying the percent of such population (80%) for the province of Ontario to the population of the Greenbelt.

[9] See Ontario Ministry of Natural Resources and Forestry, "Southern Ontario Land Resource Information System (SOLRIS)."

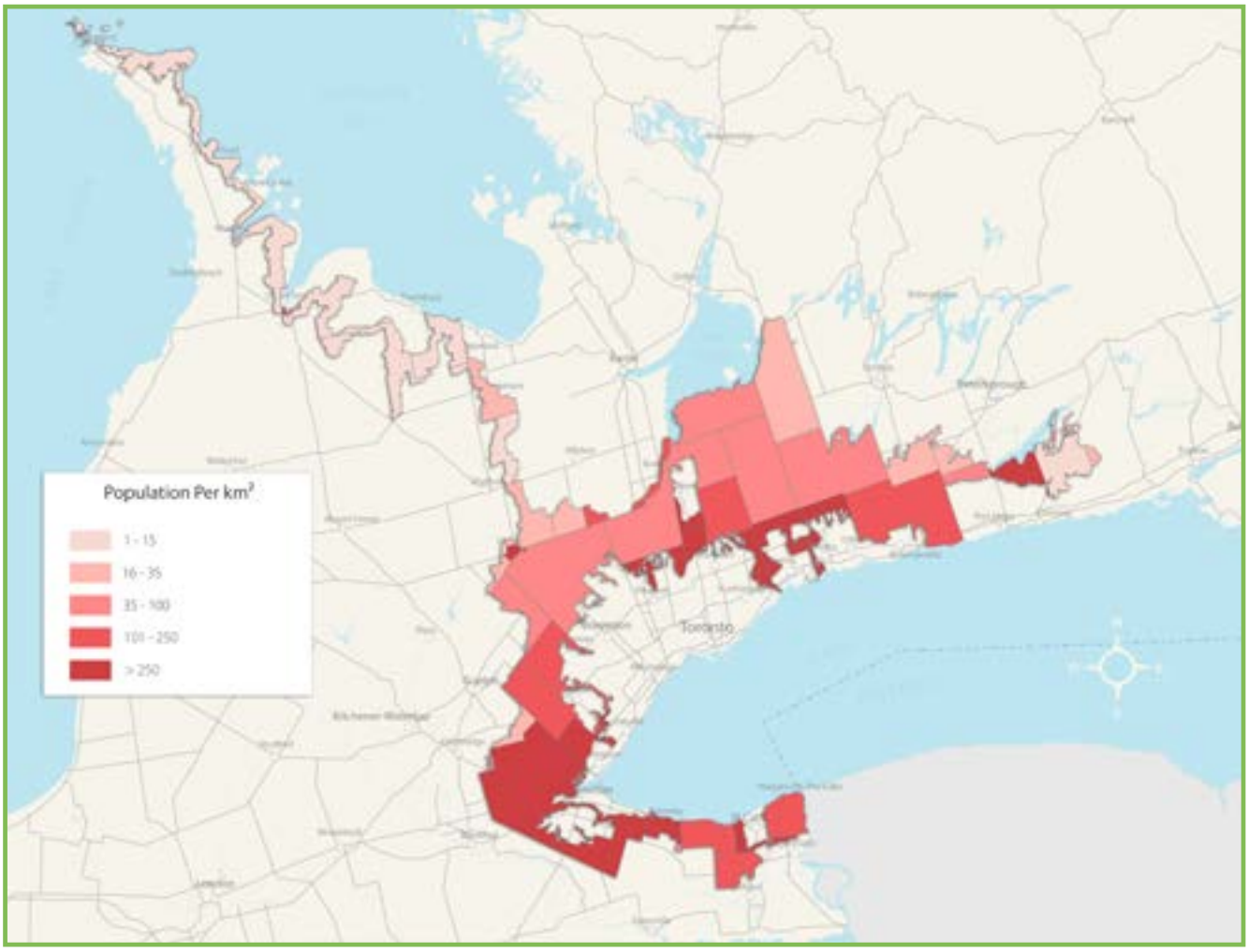


Figure 2: Population Density in the Census Subdivisions Overlapping Ontario's Greenbelt

Table 5: Changes in Land Cover in the Greenbelt, 2000 to 2011

Land Cover Shift	Change in Area (ha)	Percent of Total Change between 2000 and 2011(%)	Percent of Greenbelt Area in 2011(%)
Non-vegetation Transition Terrestrial Use			
Built Up Area-Impervious to Built Up Area-Pervious	11.6	0.25	0.001
Built Up Area-Pervious to Built Up Area-Impervious	67.9	1.46	0.009
Extraction (aggregates) to Water	0.3	0.01	0.000
Agriculture to Built Up Area-Impervious	2,385.8	51.30	0.300
Agriculture to Built Up Area-Pervious	482.6	10.38	0.061
Agriculture to Extraction (aggregates)	427.2	9.19	0.054
Agriculture to Water	5.7	0.12	0.001
Water to Agriculture	7.1	0.15	0.001
Vegetation Gain			
Built Up Area-Impervious to Built Up Area-Pervious	2.8	0.06	0.000
Extraction (aggregates) to Built Up Area-Pervious	1.3	0.03	0.000
Extraction (aggregates) to Agriculture	35.1	0.76	0.004
Wetland Loss			
Wetland to Built Up Area-Impervious	36.6	0.79	0.005
Wetland to Built Up Area-Pervious	4.7	0.10	0.001
Wetland to Extraction (aggregates)	54.9	1.18	0.007
Wetland to Extraction (aggregates and peat/topsoil)	138.1	2.97	0.017
Wetland to Transportation	2.7	0.06	0.000
Wetland to Agriculture	360.3	7.75	0.045
Woodland Loss			
Woodland to Built Up Area-Impervious	146.8	3.16	0.018
Woodland to Built Up Area-Pervious	25.5	0.55	0.003
Woodland to Extraction (aggregates)	201.2	4.33	0.025
Woodland to Extraction (aggregates and peat/topsoil)	1.0	0.02	0.000
Woodland to Transportation	13.7	0.29	0.002
Woodland to Agriculture	223.4	4.80	0.028
Total Area Change	**4,650.6**	**100.00**	**0.585**

3

Recent Advances in Natural Capital Assessments

Since the publication of *Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services* in 2008, a number of important advances have been made in the science and practice of natural capital assessment and valuation. These advances are:

- An increased focus on *final* services;
- New tools for estimating the services and their value; and,
- Improved data to support natural capital assessments and valuation.

3.1 Increased Focus on Final Services

Natural capital assessments and valuations are increasingly focused on the final services provided by ecosystems. This is in contrast to the historical focus on ecosystem production and functions which tend to be centered on the provision of intermediate, rather than final, services.[10,11] Recent natural capital assessments tend to employ new classification protocols for grouping, presenting and analyzing final services; such as the Common International Classification of Ecosystem Services (CICES) - developed by the European Environmental Agency,[12] the Final Ecosystem Goods and Services Classification System (FEGS-CS) - developed by the U.S. Environmental Protection Agency,[13] and the National Ecosystem Services Classification System (NESCS) - developed by the U.S. Environmental Protection Agency.[14]

> Building on these recent advancements, the current assessment of the natural capital in Ontario's Greenbelt **focuses on the final services** derived from the natural capital, and is **based on the National Ecosystem Services Classification System (NESCS).**

3.2 Development of New Tools

The means by which ecosystem services are estimated have been enhanced, with an increased emphasis on:

- The importance of linking appropriate biophysical indicators of final goods and services with social outcomes (i.e. impacts on beneficiaries).

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[10] James Boyd, Paul Ringold, Alan Krupnick, Robert Johnston, Matthew Weber & Kim Hall, "Ecosystem Services Indicators: Improving the Linkage between Biophysical and Economic Analyses," 2015, RFF DP 15-40.

[11] Brendan Fisher, R. Kerry Turner & Paul Morling, "Defining and Classifying Ecosystem Services for Decision Making," Ecological Economics, Vol. 68(2009), p.643-653.

[12] Roy Haines-Young & Marion Potschin, "Common International Classification of Ecosystem Services (CICES, Version 4.1)" (Copenhagen: European Environmental Agency, 2012)

[13] Dixon H. Landers & Amanda M. Nahlik, "Final ecosystem goods and services classification system (FEGS-CS)." (Washington: United States Environmental Protection Agency, 2013).

[14] "National Ecosystem Services Classification Framework Design and Policy Application," US Environmental Protection Agency, last modified December 9, 2015, http://www.epa.gov/eco-research/national-ecosystem-services-classification-system-framework-design-and-policy.

- State-of-the-art modelling tools that link biophysical processes that result in ecosystem services to those who benefit from those services. Examples of such modelling tools include:
  - InVEST[15]
  - Agent-based modelling
  - Meta-analysis

Building on recent advancements, the current assessment of the natural capital in Ontario's Greenbelt focuses on the **impact of the service**s derived from the natural capital on the people living in and around the Greenbelt and employs **leading modelling tools.**

3.3 Improved Data

Finally, the data available for use in natural capital assessments and valuations have improved. Examples of improvements of particular relevance to this assessment of natural capital include:

- A new version of SOLRIS depicting Southern Ontario Land Cover as of 2011.
- Improvements in remote sensing have developed new agricultural data sources (AAFC Annual Crop Inventory 2013 data for Ontario)[16] which can be utilized to provide a more robust delineation of the services derived from specific agricultural crops.
- The release of the 2012 *Canadian Nature Survey* [17] has updated and expanded upon the 1996 *Importance of Nature to Canadians* study.

Building on these recent advancements, the current assessment of the natural capital in Ontario's Greenbelt uses the **most up to date data** for land cover, agriculture production and recreation/ tourism spending.

[15] "InVEST: Integrated Valuation of Ecosystem Services and Tradeoffs," Natural Capital Project, accessed October 4, 2016, http://www.naturalcapitalproject.org/invest/.
[16] "Annual Crop Inventory, 2009-2015," Government of Canada (Ottawa: Agriculture and Agri-Food Canada, 2013), http://open.canada.ca/data/en/dataset/ba2645d5-4458-414d-b196-6303ac06c1c9.
[17] "2012 Canadian Nature Survey: Awareness, Participation, and Expenditures in Nature-based Recreation, Conservation, and Subsistence Activities," Federal, Provincial, and Territorial Governments of Canada (Ottawa: Canadian Councils of Resource Ministers, 2014), http://www.biodivcanada.ca/default.asp?lang=En&n=2a0569a9-1.

4 Conceptual Framework and Approach

Over the last decade there has been a dramatic rise in the valuation of natural capital and ecosystem services for the purpose of public policy and decision making. Some of these approaches, the *Millennium Ecosystem Assessment* for example, have been criticized for mixing ecosystem process and functions with ecosystem services, which is problematic if such concepts are intended to inform trade-offs and be used in the decision making process. This chapter describes the importance of intermediate services, final services, and benefits. As well, it explores some of the existing frameworks to account for these and concludes by summarizing the overall approach used for the analysis.

4.1 Understanding Intermediate Services, Final Services, and Benefits

If the objective of natural capital valuation is to track, measure, and account for the contribution of natural assets to the wellbeing of a region, it is essential that what is valued is based on a systematic approach that focuses on final (or end) benefits to beneficiaries. For example, consider the conventional system of national accounting. The calculation of gross domestic product focuses only on the final good produced (e.g. computer), and not the components used to make the computer (e.g. glass, metals, plastic, etc.). Since the value of the glass, metals, and plastic components are already included in the value of the computer, including these components would result in double counting. As argued by Boyd and Banzhaf (2007), the same principle holds with ecosystem services (emphasis added):[19]

> *Clean drinking water, which is consumed directly by a household, is dependent on a range of intermediate ecological goods, but these intermediate goods should not be counted in an ecosystem service account. Many, if not most, components and functions of an ecosystem are intermediate products in that they are necessary to the production of services but are not services themselves.* ***We emphasize that this does not mean these intermediate products are not valuable, rather that their value is embodied in the measurement of final ecosystem services.*** *Thus, final services should be the top priority in developing accounting units.*

Final services have been defined in a few different ways. Boyd and Banzhaf (2007) defined them as the "components of nature, directly enjoyed, consumed, or used to yield human wellbeing".[20] Fisher et al. (2009) defined final ecosystem services as "aspects of ecosystems utilized (actively or passively) to produce human wellbeing."[21] Regardless of the definition, the purpose of final ecosystem services is to clearly distinguish between

[18] Ken J. Wallace, "Classification of Ecosystem Services: Problems and Solutions," Biological Conservation, Vol. 139 No. 3-4(2007), p.235-246.
[19] Boyd & Banzhaf, "What are Ecosystem Services?"
[20] Ibid.
[21] Fisher, Turner & Morling, "Defining and Classifying Ecosystem Services for Decision Making."

ecological processes and functions (e.g. nutrient cycling) and the associated final services (e.g. provision of clean water) that provide value to a beneficiary. The concept of final ecosystem services also helps to more clearly identify the point within the social-environmental system where the existence of ecosystem conditions triggers improvements to human wellbeing.

Intermediate ecosystem services are thus necessary supporting conditions, processes and functions that result in final ecosystem services. For instance, a variety of intermediary services such as the regulation of water quality from surrounding forests and wetlands, nutrient cycling, and biodiversity produce final ecosystem services such as clean-water provision, fish populations, and river valley landscapes. These final services produce recreational angling benefits that are the measurable improvements to human wellbeing. In some cases, such as recreational angling, realizing the benefits to human wellbeing also requires the use of economic goods (e.g. boats, fishing rods, and tackle). The figure below depicts this relationship. It is important to note that despite the fact that intermediary services are not specifically quantified, they are still fundamental to the overall value system.

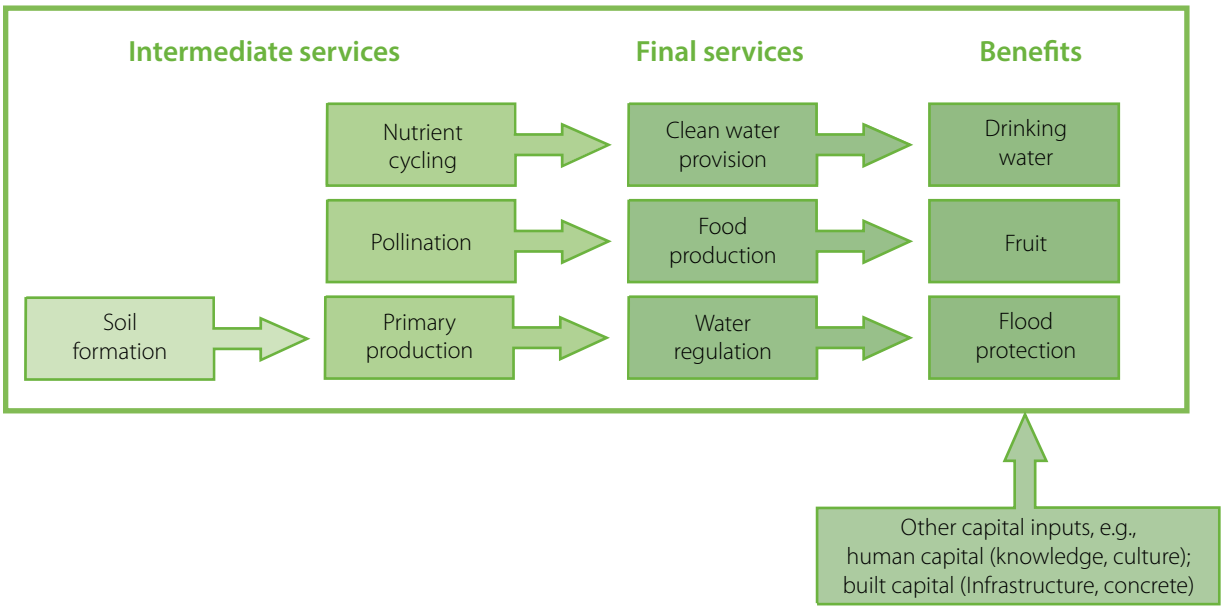

Figure 3: Relationship between Intermediate Services, Final Services, and Benefits[22]

While the concept of final ecosystems has become the standard approach in defining and valuing ecosystem services, it is not always clear which services are final and which are intermediary. Carbon sequestration is one such example.

[22] Source of Figure: Brendan Fisher, et al., "Ecosystem Services and Economic Theory: Integration for Policy-Relevant Research," Ecological Applications, Vol. 18. No. 8(2008), p.2050-2067.

The *United Kingdom National Ecosystem Assessment: Technical Report* defines climate regulation as a final service on the grounds that it reduces the adverse impacts of climate change.[23] In contrast, the United States Environmental Protection Agency considers it an intermediary good since "the average person does not use, consume, or enjoy carbon sequestration."[24] For the purpose of this study, carbon sequestration is valued, given its importance in relation to climate policy discussions in Ontario, but is considered an intermediate service and is hence excluded from the sum of the services derived from the Greenbelt's natural capital. Pollination is another service that is often considered an intermediary service contributing to the production of agricultural products.[25] The current study accounts for pollination by estimating the direct value provided to beneficiaries – the agricultural producers who benefit from the pollination services provided by the surrounding ecosystem. In other words, the value of the fruit production provided by pollination. If the assessment was to include agricultural goods more broadly, the value of pollination would be captured in the value of the final agricultural goods.

4.2 Final Ecosystem Service Classification

Despite some of the practical complexities associated with distinguishing between intermediate and final services, three dominate conceptual frameworks focused explicitly on final services have emerged:

1. Common International Classification of Ecosystem Services (CICES) - developed by the European Environmental Agency,[26]
2. Final Ecosystem Goods and Services Classification System (FEGS-CS) - developed by the U.S. Environmental Protection Agency,[27] and
3. National Ecosystem Services Classification System (NESCS) - developed by the U.S. Environmental Protection Agency. [28]

After a thorough review of the three systems identified above, the NESCS was selected as the basis of classification for the current study. The main objective of NESCS is to provide a framework that will aid in analyzing the human welfare impacts of policy-induced changes to ecosystems. The NESCS thus focuses on flows of final ecosystem services, that are defined as the direct contributions made by nature to human production processes or to human wellbeing. For both economic and environmental accounting, this distinction is essential to avoid double counting services.

While the other two systems also provide a focus on final ecosystem services, a couple of limitations guided the decision to choose NESCS. The CICES does not fully distinguish between (1) what is provided by natural systems, (2) how these natural systems and outputs are used by humans and (3) what is produced by human systems. These attributes were important given our objective of focusing on beneficiaries of the Greenbelt. The FEGS-CS is closely related to NESCS, however, its structure implies that all of the accounts are treated as stocks. For this project, the flow of ecosystem services from the Greenbelt to the beneficiaries is important to capture.

[23] Pete Smith, et al., "Chapter 14: Regulating Services" in UK National Ecosystem Assessment: Technical Report (Cambridge: UNEP-WCMC, 2011), http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx.
[24] "Final Ecosystem Goods and Services Classification System."
[25] Boyd & Banzhaf, "What are Ecosystem Services?"
[26] Haines-Young & Potschin, "Common International Classification of Ecosystem Services (CICES, Version 4.1)."
[27] "Final Ecosystem Goods and Services Classification System."
[28] "National Ecosystem Services Classification Framework Design and Policy Application."

Finally, the NESCS appeared to provide the strongest intuitive link between environmental goods and services (i.e., the supply side) and the beneficiaries (i.e., the demand side). The figure below depicts the links between environmental goods and services, and beneficiaries as captured by the NESCS framework.

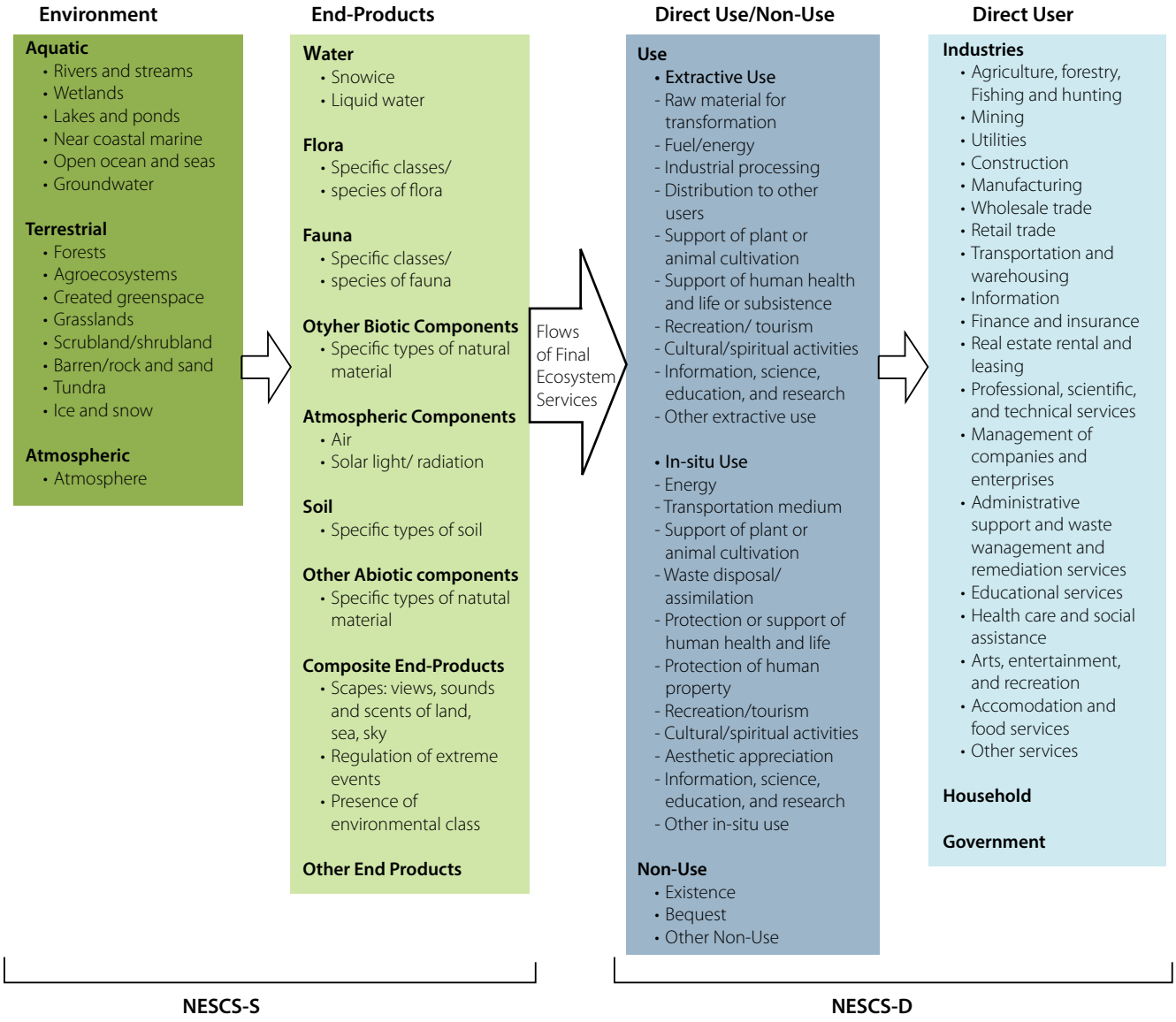

Figure 4: Depiction of the NESCS Linkages between Environmental Goods and Services (NESCS-S, where S = supply) and Beneficiaries (NESCS-D, where D = demand)

In the NESCS, final ecosystem goods and services are captured as distinct pathways linking the ecological systems that produce ecosystem services to the human systems that directly use them. The NESCS uses the concept of the flow of final services that are generated through unique linkages between the supply of ecosystem services (generated by the environment and associated end-products) and the demand for ecosystem services (generated by specific direct use or non-use from specific user types). Using the NESCS, an accounting framework for the assessment and valuation of the natural capital in Ontario's Greenbelt was developed (described below).

4.3 Natural Capital Accounting Framework for Ontario's Greenbelt

The approach employed in this study started with a list of services that are applicable to the Greenbelt, and then examined who benefits from them and the degree to which they benefit. The result is a Greenbelt-specific "system of accounts" that is more theoretically grounded relative to systems that do not focus on final ecosystem services.[29,30] The NESCS framework was used to develop customized accounts through completion of the following steps:

1. Extract a list of ecosystem service accounts from the NESCS.
2. Identify the sub-set of ecosystem service accounts that are relevant to the Greenbelt.
3. Identify the sub-set of accounts that can be quantified with existing information.
4. For the quantifiable accounts, identify who the associated beneficiaries are.
5. Value the degree to which people benefit from the natural capital in the Greenbelt by quantifying the relevant accounts.

The Greenbelt accounts established through the steps above were separated into three environment categories as per the NESCS – aquatic, terrestrial and atmospheric. In total, 39 aquatic accounts, 63 terrestrial accounts, and 1 atmospheric account were identified, of which 26, 38, and 1 respectively, were valued. A detailed listing of accounts was compiled in which each was characterized as aquatic, terrestrial or atmospheric, as well as by end-product, use or non-use, beneficiary, and market or non-market in nature (see Appendix 3).

The general process used to quantify each account entailed:

1. Assessing beneficiaries (end users of the ecosystem service flows) by considering the following questions:
   - Who are the beneficiaries?
   - Where they are located?
   - How many beneficiaries are there?
2. Determining the quantity of services being utilized by the beneficiaries (e.g. days of recreation, reduction in air pollution, or volume of water used). The estimated quantity of services used was made as spatially explicit as possible.
3. Determining the value of final ecosystem service flows. For the purpose of this assessment these values were determined using value transfer techniques[31] guided by the following rules:
   - Values were transferred from Ontario-based research first, Canadian-based research second, and other jurisdictions third.
   - Value function transfer methods were used over unit value transfers as research shows that function transfers result in a much lower transfer error.[32]

While the assessment and valuation approach employed in this study focuses explicitly on the final goods and services derived from the natural capital of the Greenbelt, the importance of intermediate services should not be dismissed. Given the question as to whether carbon storage and sequestration should be considered an

[29] Boyd, Ringold, Krupnick, Johnston, Weber, & Hall," Ecosystem Services Indicators."
[30] Fisher, Turner & Morling, "Defining and Classifying Ecosystem Services for Decision Making"
[31] Value transfer is the use of research results from a pre-existing primary valuation study to predict the value of unstudied sites or areas. For a detailed background on value transfer see Johnston, Rolfe, Rosenberger, & Brouwer, Benefit Transfer of Environmental and Resource Values.
[32] Ibid.

intermediate or final service, and the significant ability of the Greenbelt to provide these services, an assessment of these services is necessary for a complete understanding of the value of the Greenbelt. Therefore, in addition to the final goods and services that were considered as part of the natural capital assessment, the value of carbon storage and sequestration in the Greenbelt was estimated separately.

For each of the 65 accounts that were valued for the Greenbelt, the specific approach to valuation varied somewhat. In general, the objective was to employ the most recent data available as well as the best analytical tools reasonably possible. Specific data sources and approaches for each account (or group of accounts) are presented in the results chapters of this report (Chapters 5, 6 and 7). Dollar values are 2015, Canadian dollars, unless otherwise noted.[33]

Comparison of Methodology with the 2008 Study

The focus in the current study on the final services derived from the natural capital of the Greenbelt stands in contrast to a previous study on this topic. The two studies take different approaches to valuing the services derived from the natural capital of Ontario's Greenbelt, both with the most accepted standard methodology of the time.

In keeping with recent developments in the field of ecosystem service assessment and valuation, this study focuses on final ecosystem services. This method first identifies services provided by a defined area, in this case the Greenbelt, and calculates a value for them based upon who benefits from them and to what degree. This results in a Greenbelt-specific "system of accounts" that is easier to update and can be adapted to other jurisdictions. As has been noted in recent literature, this approach is also more theoretically grounded than previous approaches.

In contrast, the 2008 study, largely relies on land cover information as the basis for identifying the ecosystem services provided by any given area (i.e. the study linked dollar per ha estimates of services for specific land cover types with the area those types occupied in the Greenbelt). Thus, while the previous study told the story of the land, the current study tells the story of the people and how they benefit from the land.

The divergence between the two approaches results in some variations between the services that were valued in the two studies. The current study, for example, includes estimates of the value derived by people from non-timber products, livestock grazing, and the contribution to crop irrigation that were not included in the previous study. At the same time, some services that were included in the previous study are not included in the current one. These include, for example, water regulation, water filtration, erosion control, sediment retention, nutrient cycling and waste treatment. Some of these services were excluded from the current study because they are considered intermediate, rather than final, services (e.g. nutrient cycling), others were excluded due to lack of usable data (e.g. waste treatment), or were captured indirectly in the water use account estimates (e.g. erosion control and sediment retention). In the case of the latter, when interpreting the value estimates, it is important to note that while intermediary services have not been specifically quantified, the role they play in contributing to final services would be included. As an example, water purification and erosion control result in improved water quality, which in turn provides a higher quality for recreational uses and drinking water. A detailed comparison of specific results is provided in Appendix 4.

[33] The process for converting currency was to first convert from foreign currency to Canadian dollars based on the exchange rate at time of the original value. Once in Canadian dollars, all values were converted to 2015 CAD using the average annual Ontario consumer price index.

5 Greenbelt Aquatic Accounts

This chapter presents the results of the valuation of the aquatic accounts of the Greenbelt. The series of tables that follow, list the accounts that were deemed relevant to the Greenbelt. The accounts are grouped by NESCS subclass (watercourse, wetland and groundwater).

5.1 Watercourse Subclass

The table below identifies the aquatic accounts for the watercourse[34] subclass (i.e. rivers, streams and wetlands) that are relevant to the Greenbelt. Value estimates are presented for each of the accounts highlighted in green.

Table 6: Greenbelt Aquatic Accounts, Watercourse Subclass

End-products	Use / Non-use	Use / Non-use subclass	Specific Use / Non-use	Beneficiary
Water	Extractive use	Support for plant cultivation	Crop irrigation	Industry
	Extractive use	Support for animal cultivation	Water for livestock	Industry
	Extractive use	Industrial processing	Specific industrial uses	Industry
	Extractive use	Support of human health and life	Drinking water	Household
	In-situ use	Energy		Industry
	In-situ use	Waste disposal/assimilation		Industry
	In-situ use	Recreation/tourism	Canoeing/kayaking	Household
	In-situ use	Recreation/tourism	Swimming	Household
	In-situ use	Recreation/tourism	Ice skating	Household
	Non-use	Existence and bequest		Household
Flora	Non-use	Existence and bequest		Household
Fauna	In-situ use	Recreation/tourism	Angling	Household
	Non-use	Existence and bequest		Household
Composite end-products	In-situ use	Aesthetic appreciation		Household
	Non-use	Existence and bequest		Household
	In-situ use	Information, science and education		Government
	In-situ use	Aesthetic appreciation		Household

[34] For the purpose of this analysis a watercourse is considered to be the interconnected network of streams, rivers, lakes and ponds that exist throughout the Greenbelt.

5.2 Wetland Subclass

The table below identifies the aquatic accounts for the wetland subclass that are relevant to the Greenbelt. Value estimates are presented for each of the accounts highlighted in green.

Table 7: Greenbelt Aquatic Accounts, Wetland Subclass

End-products	Use / Non-use	Use / Non-use subclass	Specific Use / Non-use	Beneficiary
Water	In-situ use	Information, science and education		Government
	In-situ use	Waste disposal/assimilation		Industry
Flora	Non-use	Existence and bequest		Household
	Extractive use	Recreation/tourism	Waterfowl hunting	Household
	In-situ use	Recreation/tourism	Birdwatching	Household
	Non-use	Existence and bequest		Household
	In-situ use	Recreation/tourism	Angling	Household
	Non-use	Existence and bequest		Household
Composite end-products	In-situ use	Aesthetic appreciation		Household
	In-situ use	Recreation/tourism	Canoeing/kayaking	Household
	Non-use	Existence and bequest		Household
	In-situ use	Protection of human health and life	Avoided drowning*	Household
	In-situ use	Protection of human property	Avoided crop damage*	Industry
	In-situ use	Protection of human property	Avoided damage to vehicles*	Household
	In-situ use	Protection of human property	Avoided residential damages*	Household
	In-situ use	Protection of human property	Avoided ICI damages*	Industry

*Due to reduced flood risk

5.3 Groundwater Subclass

The table below identifies the aquatic accounts for the groundwater subclass that are relevant to the Greenbelt. Value estimates are presented for each of the accounts highlighted in green.

Table 8: Greenbelt Aquatic Accounts, Groundwater Subclass

End-products	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary
Water	Extractive use	Support of human health and life	Drinking water	Household
	Extractive use	Raw material for transformation	Beverage production	Industry
	Extractive use	Support for plant cultivation	Crop irrigation	Industry
	Extractive use	Support for animal cultivation	Water for livestock	Industry
	Extractive use	Industrial processing	Specific industrial uses	Industry
Composite end-products	Non-use	Existence and bequest		Household

5.4 Valuation of Accounts

Value estimates for the Greenbelt aquatic accounts (highlighted in green in the Tables 6, 7 and 8) are presented below. The accounts are grouped into a series of sub-categories – recreation/tourism, protection of human property, existence and bequest, and extractive uses.

5.4.1 Recreation/Tourism

Values were derived for a number of recreation/tourism activities of relevance to the aquatic accounts for the Greenbelt, in particular, for:

- Non-motorized water (canoe and kayaking) and beach (swimming),
- Angling; and,
- Waterfowl hunting.[35]

For each of these aquatic-based recreational activities, value estimates were derived using expenditure estimates as presented in the 2012 Canadian Nature Survey.[36] To generate expenditure estimates specifically for the Greenbelt, a number of factors were taken into consideration. First, the adult (aged 18 and over) population within a 20 km radius of the Greenbelt was calculated.[37] Participation rates for the various aquatic-based recreation activities were applied to the population figure to estimate the number of people within a 20 km radius of the Greenbelt that participate in each particular activity of interest. Ontario-specific participation rates for each activity are shown in the Table 9.[38]

[35] For the purpose of the aquatic recreation value we focus on waterfowl hunting only. Other hunting terms are used throughout this Section which relate to specific statistics from the 2012 Canadian Nature Survey. These provide additional context and in some cases are used to narrow the provincial waterfowl hunting data to an approximation of could be attributable to the Greenbelt.
[36] "2012 Canadian Nature Survey."
[37] To be conservative, expenditure estimates are based on the number and type of local people taking day trips to the Greenbelt for the purpose of recreation (expenditures associate with over-night trips are not captured in this analysis). For consistency with the Canadian Nature Survey, a 20 km radius was chosen as the cut-off for that which constitutes a day trip.
[38] "2012 Canadian Nature Survey."

Table 9: Percentage of Ontario Residents (aged 18 and older) Participating in (select) Nature-related Activities

Activity	Participation (%)
Non-motorized water and beach	42
Angling	21
Hunting	5

The resulting population figures below describe the number of adults living within a 20 km radius of the Greenbelt who participate in each aquatic-based recreation activity. The portion of that population that participates in day trips (as opposed to overnight trips) was then derived. According to the 2012 Canadian Nature Survey:

- 73% of nature-based recreation is near home (within 20 km);
- 49% of hunting and trapping is near home (within 20 km); and,
- 54% of fishing is near home (within 20 km).

The figures above were assigned to the number of adults participating in the respective aquatic-based recreation activities (nature-based recreation was assigned to non-motorized water and beach) to derive estimates for the number of participants within a 20 km radius of the Greenbelt participating in the relevant activities near home (within 20 km). The number of days spent recreating near home for each of the aquatic-based recreation activities (Table 10) was then applied to the number of participants undertaking the activities to derive estimates of the total number of days in a year dedicated to each of the activities within the Greenbelt.

Table 10: Average Participation Days in Nature, Near Home and Away from Home, per Participant, Ontario and Canada*

Activity	Days Near Home	Days Away Home	Total Days
Non-motorized water and beach*	19	12	31
Hunting	17	18	35
Fishing (angling)	14	12	26

*Average values for Canada were used due to lack of disaggregation in the Ontario-specific data

This results in an estimate for the number of days of recreation for the adult population within 20 km of the Greenbelt. However, it is uncertain where exactly the recreation activities occur. If they occur outside the Greenbelt, then the recreation estimates will be overvalued. Without more detailed information on the specific location of the recreational activities, it is difficult to determine how much of this value is attributable to the Greenbelt.

Given that the population accounts for only those people that live no further than 20 km from Greenbelt, it is possible that much of the recreation activity is occurring in the Greenbelt. However, it is also likely that at least some of these recreation days are not occurring within the Greenbelt. To address this uncertainty, three scenarios were developed that adjust the number of recreation days occurring near home based on the likelihood of the activity occurring within the Greenbelt. To determine the likelihood of an activity occurring within the Greenbelt, a detailed data set of recreation access points, boat launches, campgrounds, and trail heads in Ontario was used to estimate a proxy likelihood. This was done by determining the ratio of the number of recreation points within the Greenbelt relative to the total number of points within all census subdivision of the Greenbelt. This resulted in a 51% likelihood that recreation occurs within the Greenbelt. Three scenarios for recreation benefits were then derived:

1. Upper Bound: This assumes that all recreation days that occur near home, occur within the Greenbelt .[39]
2. Adjusted Estimate: This assumes that recreation days for most activities occur within the Greenbelt, except for hiking, birding, cycling, and non-motorized water and beach, which are adjusted for the likelihood the activity occurs in the Greenbelt. This estimate was used as the value for the recreation accounts.
3. Lower Bound: This adjusts all recreation days by the likelihood that the activity occurs in the Greenbelt.

Daily expenditure estimates (adjusted to account only for expenditures associated with equipment, fees, and supplies) from the 2012 Canadian Nature Survey were then applied to the number of days to generate total expenditure estimates by activity.[40] The table below presents Greenbelt specific expenditure estimates for each of the aquatic-based recreation activity.

Table 11: Number of Participants, Annual Days and Expenditure on Recreation Activities in the Greenbelt

Activity	Number of Participants who Recreate in the Greenbelt	Annual Expenditure on Recreation in the Greenbelt ($Million)		
		Upper Bound	Adjusted Estimate	Lower Bound
Non-motorized water and beach	2,264,919	318.2	162.3	162.3
Angling	835,632	179.5	179.5	91.6
Waterfowl hunting	179,470	41.4	41.4	21.1
Total		**539.2**	**383.2**	**275.0**

[39] The province recently announced the expansion of the Greenbelt to include urban river valleys through the GTA. Once these river valleys are formally incorporated into the Greenbelt, the upper bound estimate is likely to be more reflective of recreational values.
[40] Expenditures associated with transportation, accommodation and food were excluded because of the focus on particular costs associated with activities near home as opposed to away from home.

A Note About Double Counting
Double counting is an issue in the valuation of nature-based activities. According to the Canadian Nature Survey, estimates of the rate of participation in an overall category of nature recreation only counts a survey respondent as a participant if he or she indicated at least one day of participation in any of the activities. This prevents double-counting respondents who indicated participation in more than one such activity within a category. The risk of double counting was further mitigated in the Nature Survey by considering only the expenditures on equipment, fees, and supplies. In other words, expenditures such as transportation and accommodation that may apply to more than one activity in a trip were not considered.

5.4.2 Protection of Human Property

The protection of human property captures the role and value of wetlands in regulating flood damages in the region. Ideally, these values would be determined by carefully quantifying the hydrological function of wetlands within the context of each watershed within the Greenbelt, and the number of properties and other built infrastructure located within flood zones downstream of those wetlands. While this is technically possible, such an analysis was beyond the scope of the current project. Consequently, an alternative approach relying on the vast amount of research conducted to date on the value of wetlands was employed.

Through a detailed review of the existing literature, a meta-analysis focused on the regulating services provided by wetlands within agricultural landscapes was identified.[41] The study (Brander et. al., 2013) statistically assessed 66 wetland value estimates largely from Europe and the United States. The resulting meta-regression model estimates wetland values (measured in dollars per ha per year) based on a series of dependent variables:

- The service of interest (flood control, water supply, or water quality).
- The area of the individual wetland being valued, measured in ha.
- The abundance of wetlands in the surrounding area capturing the impact of substitute sites, measured as the total area of wetlands within 50 km of the target wetland being valued.
- The population in the surrounding area.
- The amount of economic activity in the surrounding area, measured by gross domestic product within the area.[42]

Using this meta-regression model, the value of flood control provided by wetlands in the Greenbelt was estimated on a wetland by wetland basis. To do so, the Province of Ontario's official Wetlands Mapping was used.[43] Using this data, all wetlands within the Greenbelt were identified. For the purpose of valuation, only wetlands that have been evaluated as provincially significant were included. This resulted in a total of 15,222 individual wetlands representing 211 wetland complexes. The meta-function was applied to the wetland complex organization resulting in a unique value per ha for each complex. Table 12 summarizes the values associated with each of the 211 wetland complexes. The average value per ha of a wetland complex was $10,939. Based on the sum of each individual wetland value, the total value of protection of human property provided by all provincially significant wetlands within the Greenbelt was estimated to be $224.35 M per year.

[41] Luke Brander, Roy Brouwer & Alfred Wagtendonk, "Economic Valuation of Regulating Services provided by Wetlands in Agricultural Landscapes: A Meta-analysis," Ecological Engineering, Vol. 56(2013), p.89-96.
[42] The value of gross domestic product is measured using "gross cell product," which is the result of a spatial economic process that translates GDP estimates to 1-degree latitude by 1-degree longitude grid (or "cell") across a country or region. For more information and access to pre-processed data see: http://gecon.yale.edu/
[43] "Wetlands," Land Information Ontario, Government of Ontario, last modified August 19, 2016, https://www.ontario.ca/page/land-information-ontario

The table below provides summary statistics from the calculated values of individual wetlands and the following figure depicts the wetland values spatially across the Greenbelt.

Table 12: Summary of Flood Protection Values Provided by Wetlands

Summary Statistic	Value per ha per year	Value per wetland per year
Minimum	$1,759	$3,220
Maximum	$257,476	$5,524,906
Mean	$10,939	$1,063,290
Confidence Interval (95%)	+/- $2,718	+/- $144,377

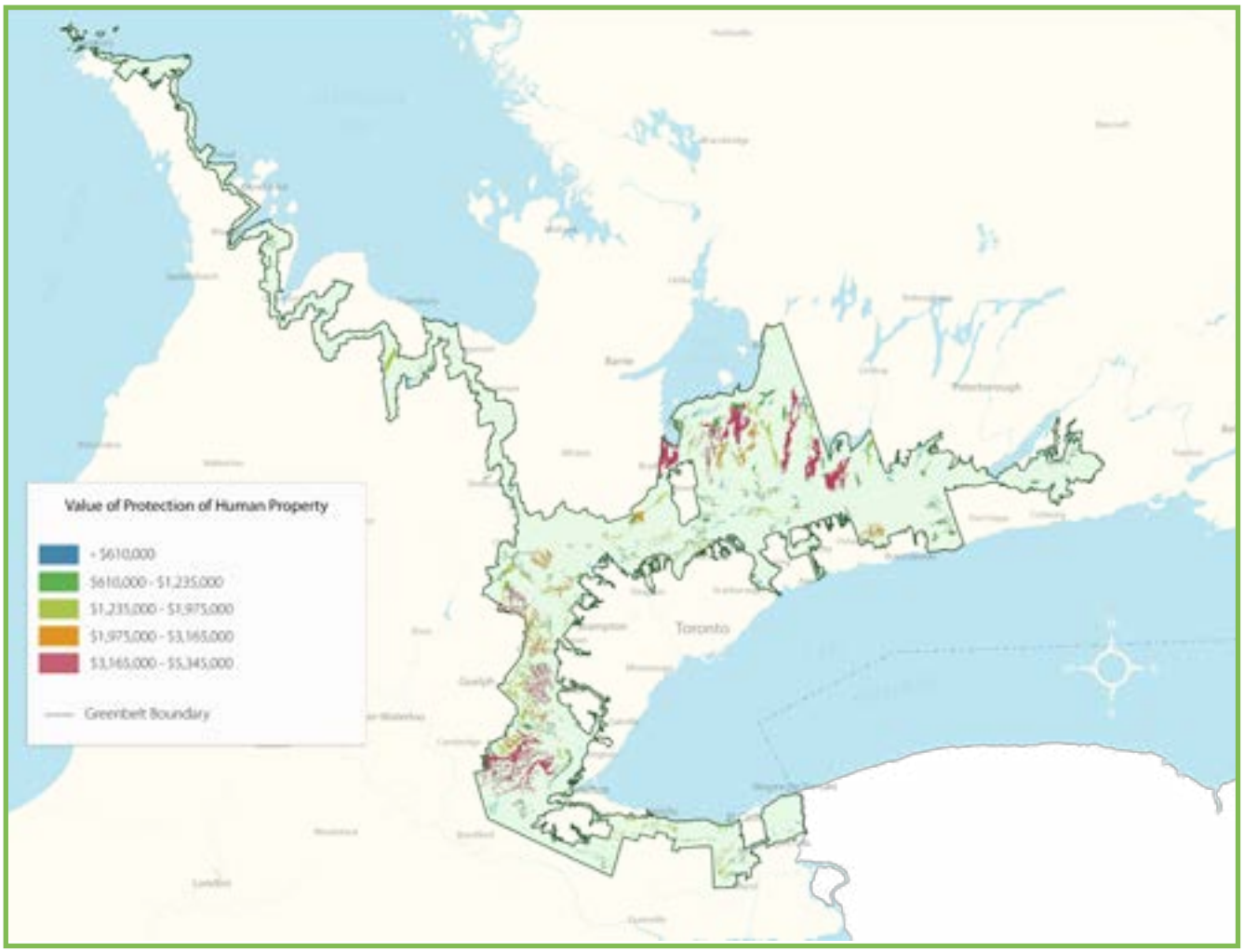

Figure 5: Protection of Human Property Values within the Greenbelt

5.4.3 Existence and Bequest

Existence and bequest values are difficult to disentangle. They collectively capture the value that people hold for the existence of environmental features for current and future generations, regardless of whether the features would ever be directly used. In theory, these values can be held for a wide range of environmental features from specific species of flora and fauna, to specific ecosystems (e.g. wetlands, forests), to broad landscapes that encompass a collection of species and ecosystems. Since conceptually these values exist at a finely disaggregated scale, the Greenbelt accounts have been structured to reflect some of this detail. However, from a valuation perspective, such a level of disaggregation is difficult to attain as a result of limitations in the valuation process and in how individuals perceive such values. A whole body of literature exists that examines the sensitivity of these values to the scope of the environmental good being studied.[44] Research demonstrates that teasing out these nested relationships depends on how studies are designed.[45] To do so for the Greenbelt would require a

[44] For example, see: Kevin J. Boyle, William H. Desvousges, Reed F. Johnson, Richard W. Dunford & Sara P. Hudson, "An Investigation of Part-whole Biases in Contingent-valuation Studies," Environmental Economics and Management, Vol. 27 No. 1(1994), p.64-83; or Richard T. Carson & Robert Cameron Mitchell, "Sequencing and Nesting in Contingent Valuation Studies," Environmental Economics and Management, Vol. 28 No. 2(1994), p.155-173.

[45] Ian J. Bateman, Matthew Cole, Philip Cooper, Stavros Georgiou, David Hadley & Gregory L. Poe, "On Visible Choice Sets and Scope Sensitivity," Environmental Economics and Management, Vol. 47 No. 1(2004), p.71-93.

study specifically designed for this purpose. In lieu of such a study, these values are determined through a single preservation value transfer for aquatic systems and a single value transfer for terrestrial systems.

The existence and bequest value of the aquatic resources (i.e. the quantity and quality of water) in the Greenbelt was measured by applying a value transfer technique. A value of $41 (adjusted to 2015 dollars) was used from a prior Canadian study and applied across the number of households in the Greenbelt and within a 20 km buffer.[46] The 20 km buffer was used because beneficiaries are not constrained solely to those residing within the Greenbelt. The number of households within the area amount to 3,007,490 and at $41 per household per year, the total existence value of the aquatic ecosystem was valued at $124.15 M per year.

5.4.4 Extractive Uses (excluding hunting)

Extractive uses include the use of water for crop irrigation and household water consumption from multiple sources including water courses, wetlands, and groundwater.

Water permit data were investigated for the purpose of valuing irrigation and other industrial water use. Despite GIS point data for specific permits, the data were not used as the permits only report the maximum capacity available by permit as opposed to actual use. While it was not possible to utilize the water permit withdrawal limits to quantify the value of water usage, it was possible to use this information to help demonstrate the spatial distribution of water usage across the Greenbelt (see Figure 6). The map highlights that areas with high densities of water taking are located throughout the Greenbelt.

[46] Diane P. Dupont & Steven Renzetti, "Good to the Last Drop? An Assessment of Canadian Water Value Estimates," Canadian Water Resources, Vol. 33 No. 4(2008), p. 369-380.

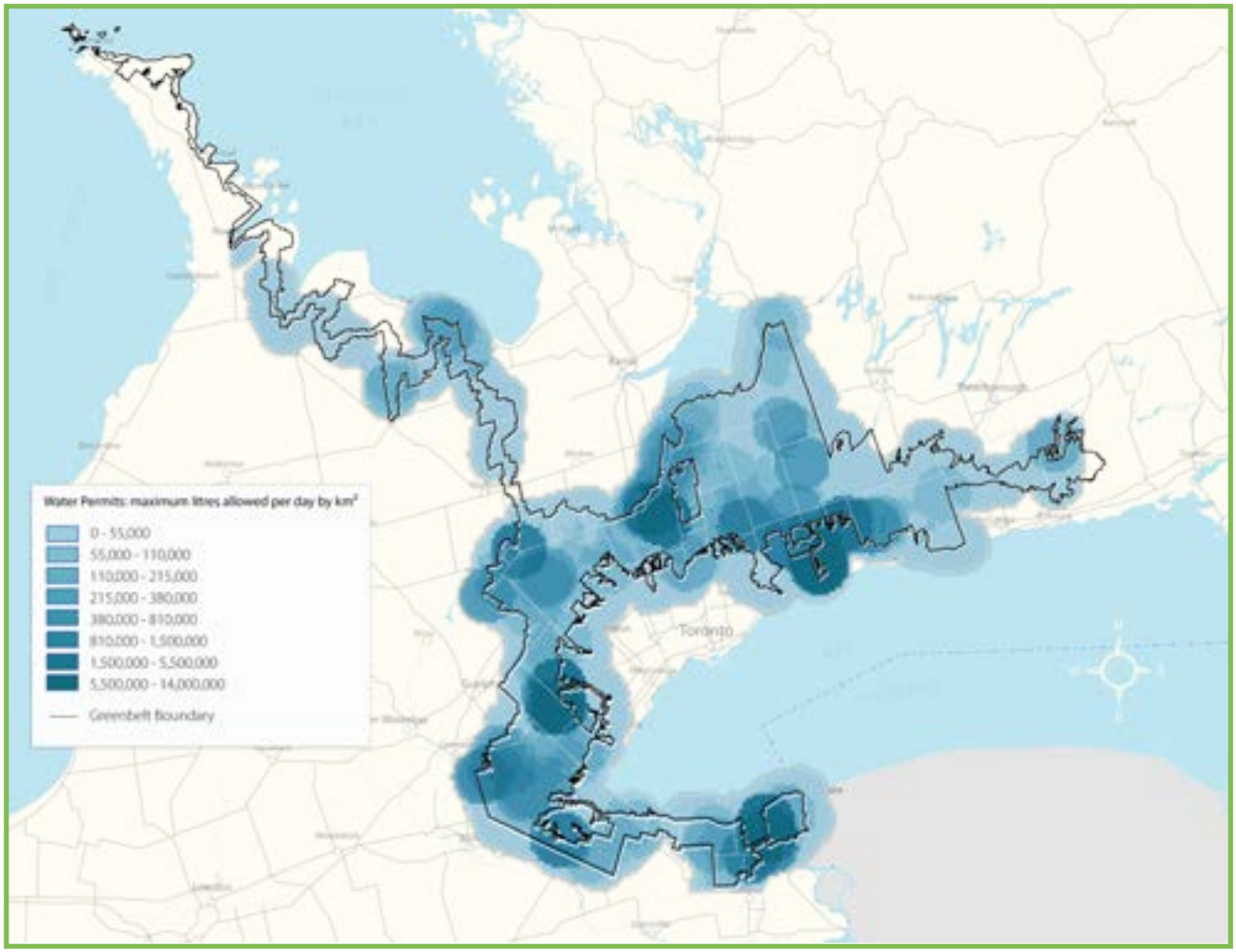

Figure 6: Spatial Distribution of Water Usage Across the Greenbelt

An alternate methodology was used to value irrigation. In this case, the average amount of water used for irrigation in Canada by hectare was applied to the ha under irrigation within the Greenbelt. These data were collected from the Census of Agriculture. According to the Census, a total of 7,877 ha were under irrigation in the Greenbelt in 2011.[47] In Canada, 770,148 ha were under irrigation with a reported use volume of 838 million cubic meters of water. In Ontario, the reported volume of irrigation water used was 20 million cubic meters with 22,290 ha of land under irrigation. The Greenbelt represents approximately 25% of irrigation by area in Ontario. Assuming the average rate of water used for irrigation is 1,088 m^3 per ha per year, the Greenbelt's water use is estimated at 8.57 million m^3. Applying an average imputed value for water of $0.74 per m^3 from previous studies yields an overall value for irrigation of $7.63 M per year adjusted to 2015 dollars ($6.34 M per year*1.2024).[48]

Water use for livestock was estimated based on the published *Canadian Regional Agriculture Water Use Module* (CRAWUM) (2007).[49] According to the 2011 Census of Agriculture, there were 3,978,188 total heads of poultry

[47] "Agricultural Water Use in Canada," Statistics Canada, last modified November 17, 2015, http://www.statcan.gc.ca/pub/16-402-x/2011001/part-partie1-eng.htm.
[48] Dupont & Renzetti, "Good to the Last Drop?"
[49] Ibid.

(i.e. chickens and turkeys) and 95,040 total heads of cattle in the Greenbelt. Coefficients of water required per animal based on the CRAWUM were 0.07 m^3 and 9.58 m^3 for poultry and cattle, respectively. Applying the same agriculture-based price of $0.74 per m^3 of water yields 2005 valuation estimates of $206,070 for poultry and $673,758 for cattle, for a total 2015 livestock valuation $1.06 M per year ($0.88 M per year*1.2024).

Water supply for households was also valued. Municipal water use was valued at $719 per household per year according to a 2008 study.[50] There were a total of 414,734 households (measured as occupied dwellings) in the Greenbelt yielding an adjusted 2015 municipal water valuation of $358.55 M per year. Of this value, approximately half is the market value and half the existence value of a reliable quantity of water supply for consumption.

Table 13: Value of Aquatic Extractive Uses

Use	Valuation Unit	Annual Value per Unit	Inflation Adjustment	Total Annual Value ($Million)
Crop irrigation	5.5 million m^3 of water	$0.74 per m^3	1.2024	7.63
Livestock	2,273,898 m^3 of water	$0.74 per m^3	1.2024	1.06
Water supply (households)	414,734 households	$719 per household	1.2024	358.55
Total Aquatic Extractive Use				**$367.24**

5.4.5 Summary of Aquatic Accounts

The table below provides a summary of the aquatic accounts for the Greenbelt. In total, the value of the aquatic accounts in the Greenbelt was estimated at $1,4457.94 M per year. Approximately half of the value is derived from the aquatic recreation accounts.

Table 14: Summary of Aquatic Use Values

Use	Total Annual Value ($Million)
Non-motorized water and beach	162.30
Angling	179.50
Waterfowl hunting	41.40
Subtotal Recreation/tourism	**383.20**
Subtotal Protection of Human Property	**224.35**
Subtotal Existence and Bequest	**124.15**
Crop irrigation	7.63
Livestock	1.06
Water supply (households)	358.55
Subtotal Extractive Use	**367.24**
Total Aquatic Use	**1,098.94**

[50] Ibid.

6 Greenbelt Terrestrial Accounts

This chapter presents the results of the valuation of terrestrial accounts of the Greenbelt. The series of tables that follow, identify the accounts that were deemed relevant to the Greenbelt. The accounts are grouped by NESCS subclass (grasslands, agroecosystem, alvar, barren rock and sand and forest).

6.1 Grassland Subclass

The table below identifies the terrestrial accounts for the grassland subclass that are relevant to the Greenbelt. Value estimates are presented for each of the accounts highlighted in green.

Table 15: Greenbelt Terrestrial Accounts, Grassland Subclass

End-products	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary
Flora	In-situ use	Aesthetic appreciation	Wild flower viewing	Household
	Extractive use	Distribution to other users	Harvest of non-cultivated flowers and seeds	Household
	Extractive use	Support for animal cultivation	Grazing of livestock	Industry
	Extractive use	Other extractive use	Edible berries	Household
Fauna	In-situ use	Recreation/tourism	Bird watching	Household
	Non-use	Existence and bequest		Household
	Extractive use	Recreation/tourism	Hunting	Household
	Non-use	Existence and bequest		Household
Fauna - pollinators	In-situ use	Support for plant cultivation	Improved crop productivity	Industry
Composite end-products	In-situ use	Protection of human health and life	Avoided drowning*	Household
	In-situ use	Protection of human property	Avoided crop damage*	Industry
	In-situ use	Protection of human property	Avoided damage to vehicles*	Household
	In-situ use	Protection of human property	Avoided residential damages*	Household
	In-situ use	Protection of human property	Avoided ICI damages*	Industry
	In-situ use	Aesthetic appreciation	Scenic views	Household
	In-situ use	Recreation/tourism	Hiking, climbing and horseback riding	Household
	Non-use	Existence and bequest		Household
	In-situ use	Information, science and education		Government
	In-situ use	Recreation/tourism	Biking	Household
	In-situ use	Recreation/tourism	Cross-country skiing and snowshoeing	Household
	In-situ use	Recreation/tourism	ATV/snowmobile	Household

*Due to reduced flood risk

6.2 Agroecosystem Subclass

The table below identifies the terrestrial accounts for the agroecosystem subclass that are relevant to the Greenbelt. Value estimates are presented for each of the accounts highlighted in green.

Table 16: Greenbelt Terrestrial Accounts, Agroecosystem Subclass

End-products	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary
Soil	In-situ use	Support of plant cultivation	Crop productivity	Industry
Fauna	In-situ use	Recreation/tourism	Bird watching	Household
Fauna - pollinators	In-situ use	Support of plant cultivation	Crop productivity	Industry
Composite end-products	In-situ use	Aesthetic appreciation	Rural countryside viewing	Household
	Non-use	Existence and bequest	Cultural value	Household
	In-situ use	Recreation/tourism	Agri-tourism	Household
	In-situ use	Recreation/tourism	Cross-country skiing and snowshoeing	Household
	In-situ use	Recreation/tourism	ATV/snowmobile	Household

*Due to reduced flood risk

6.3 Alvar Subclass

The table below identifies the terrestrial accounts for the alvar subclass that are relevant to the Greenbelt. Value estimates are presented for each of the accounts highlighted in green.

Table 17: Greenbelt Terrestrial Accounts, Alvar Subclass

End-products	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary
Flora	In-situ use	Aesthetic appreciation	Wild flower viewing	Household
	Extractive use	Other extractive use	Edible berries	Household
Fauna	In-situ use	Recreation/tourism	Bird watching	Household
	Non-use	Existence and bequest		Household
	Extractive use	Recreation/tourism	Hunting	Household
	Non-use	Existence and bequest		Household
Fauna - pollinators	In-situ use	Support for plant cultivation	Improved crop productivity	Industry
Composite end-products	In-situ use	Aesthetic appreciation	Scenic views	Household
	In-situ use	Recreation/tourism	Hiking, climbing and horseback riding	Household
	Non-use	Existence and bequest		Household
	In-situ use	Information, science and education		Government

6.4 Barren Rock and Sand Subclass

The table below identifies the terrestrial accounts for the barren rock and sand subclass that are relevant to the Greenbelt. Value estimates are presented for each of the accounts highlighted in green.

Table 18: Greenbelt Terrestrial Accounts, Barren Rock and Sand Subclass

End-products	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary
Other abiotic components	In-situ use	Recreation/tourism	Beach activities	Household
Other abiotic components	In-situ use	Recreation/tourism	Hiking, climbing and horseback riding	Household

6.5 Forest Subclass

The table below identifies the terrestrial accounts for the forest subclass that are relevant to the Greenbelt. Value estimates are presented for each of the accounts highlighted in green.

Table 19: Greenbelt Terrestrial Accounts, Forest Subclass

End-products	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary
Flora	Extractive use	Raw material for transformation	Timber[51]	Industry
	Extractive use	Energy	Fire wood	Household
	Extractive use	Other extractive use		Household
	Extractive use	Raw material for transformation	Maple sap	Industry
Fauna	Non-use	Existence and bequest		Household
	Extractive use	Recreation/tourism	Hunting	Household
	In-situ use	Recreation/tourism	Bird watching	Household
	Non-use	Existence and bequest		Household
Composite end-products	In-situ use	Recreation/tourism	Fall colour viewing	Industry
	In-situ use	Aesthetic appreciation	Scenic views	Household
	In-situ use	Recreation/tourism	Hiking, climbing and horseback riding	Household
	Non-use	Existence and bequest		Household
	In-situ use	Information, science and education		Government
	In-situ use	Protection of human health and life	Avoided drowning	Household
	In-situ use	Protection of human property	Avoided crop damage	Industry
	In-situ use	Protection of human property	Avoided damage to vehicles	Household
	In-situ use	Protection of human property	Avoided residential damages	Household
	In-situ use	Protection of human property	Avoided ICI damages	Industry
	In-situ use	Recreation/tourism	Cross-country skiing and snowshoeing	Household
	In-situ use	Recreation/tourism	ATV/snowmobile	Household
	In-situ use	Recreation/tourism	Biking	Household

[51] No datasets on timber extraction from the Greenbelt were found at the time of this study. A previous study by Econometric Research Limited on the evaluation of economic benefits of Greenbelt assets also found no workable solution to estimate the value of forestry.

6.6 Valuation Estimates

Value estimates for the Greenbelt terrestrial accounts (green) are presented below. The accounts are grouped into a series of sub-categories – recreation/tourism, support for plant cultivation, protection of human property, existence and bequest, and extractive uses.

6.6.1 Recreation/tourism

As is highlighted earlier, value estimates were derived for a number of recreation/tourism activities of relevance to the Greenbelt terrestrial accounts, including:

- Bird watching
- Hunting
- Hiking, climbing and horseback riding
- Biking
- Cross-country skiing and snowshoeing
- ATV and snowmobiling

Both golfing and alpine skiing/snowboarding also take place in the Greenbelt on its 138 golf courses and numerous ski/snowboard resorts. In Ontario, it is estimated that 23% of the adult population participates in golf and 15% of the adult population participates in alpine skiing and snowboarding. Given these participation rates, it is clear that humans derive value from undertaking these activities. It is possible that a portion of that value they derive may be attributed to the opportunity to undertake such activities in the Greenbelt specifically. However, sufficient data to derive an estimate of this value was not available.

Estimates of the value of each of the terrestrial-based activities (other than golf and alpine skiing and snowboarding) were derived using expenditure estimates from the 2012 Canadian Nature survey.[52] To generate expenditure estimates specifically for the Greenbelt, a number of factors were taken into consideration. First, the adult (aged 18 and over) population within a 20 km radius of the Greenbelt was identified.[53] Participation rates for the various terrestrial-based recreation activities were applied to the population figure to estimate the number of people that participate in the particular activities of interest. Ontario specific participation rates for the relevant activities are shown in the table below. [54]

Table 20: Percentage of Ontario Residents (aged 18 and older) Participating in (select) Nature-related Activities (20 km radius of the Greenbelt)

Activity	Participation (%)
Hiking, climbing and horseback riding	65
Cycling and mountain biking	28
Golfing	23
Birding	19
Alpine skiing and snowboarding	15
ATV and snowmobiling	12
Cross-country skiing and snowshoeing	9
Hunting wild animals	5

The resulting population figure describes the number of adults living within a 20 km radius of the Greenbelt that participate in terrestrial-related recreation activities. The portion of that population that participates in day trips (as opposed to overnight trips) was then derived. According to the 2012 *Canadian Nature Survey*:

- 81% of birding is near home (within 20 km);
- 73% of nature-based recreation is near home (within 20 km); and,
- 49% of hunting and trapping is near home (within 20 km).

The figures above were assigned to the number of adults participating in the respective terrestrial-based recreation activities. The percent of trips near home for nature-based recreation (73%) was assigned to hiking, climbing and horseback riding, cycling and mountain biking, ATV and snowmobile use, and cross-country skiing and snowshoeing to derive estimates for the number of participants within a 20 km radius of the Greenbelt participating in the relevant activities. Given that the resulting portion of participants recreate near home and also live within 20 km of the Greenbelt, the recreation that they undertake is assumed to occur within the Greenbelt area.

> "73% of nature-based recreation is near home (within 20 km)

The number of days spent recreating near home for each of the terrestrial-based recreation activities (Table 21) was then applied to the number of participants undertaking the activities near home to derived estimates of the total number of days in a year dedicated to each of the activities within the Greenbelt.

[52] "2012 Canadian Nature Survey."
[53] To be conservative, expenditure estimates are based on the number and type of local people taking day trips to the Greenbelt for the purpose of recreation (expenditures associate with over-night trips are not captured in this analysis). For consistency with the Canadian Nature Survey, a 20 km radius was chosen as the cut-off for that which constitutes a day trip.
[54] "2012 Canadian Nature Survey."

Table 21: Average Participation Days in Nature, Near Home and Away from Home, per Participant, Ontario, Canada per year*

Activity	Days Near Home	Days Away from Home	Total Days
Bird watching	113	26	139
Hunting or trapping	17	18	35
Hiking, climbing and horseback riding*	66	18	84
Cycling and mountain biking*	36	16	52
ATV and snowmobile*	32	19	51
Cross-country skiing and snowshoeing*	13	7	20

*Average values for Canada due to lack of disaggregation in the Ontario-specific data

This approach results in the number of days of recreation for adults within 20 km of the Greenbelt. However, it is uncertain where exactly the recreation activities occur. If they occur outside the Greenbelt, then the recreation estimates will be overvalued. Without more detailed information on the specific location of the recreational activities, it is difficult to determine how much of this value is attributable to the Greenbelt. As was done with the aquatic accounts, to address this uncertainty, three scenarios were developed that adjust the number of recreation days occurring near home based on the likelihood of the activity occurring within the Greenbelt. Daily expenditure estimates (adjusted to account only for expenditures associated with equipment, fees, and supplies) from the 2012 Canadian Nature Survey[55] were applied to the average number of recreation days to generate total expenditure estimates by activity.[56] The table below presents Greenbelt-specific expenditure estimates for each of the terrestrial-based recreation activities under the three scenarios.

Table 22: Number of Participants, Annual Days and Expenditure on Recreation Activities in the Greenbelt

Activity	Number of Participants who Recreate in the Greenbelt	Annual Expenditure on Recreation in the Greenbelt ($Million)+		
		Upper Bound	Adjusted Estimate	Lower Bound
Hiking, climbing and horseback riding	3,505,231	1,710.7	872.5	872.5
Hunting or trapping	179,470	35.6	35.6	18.2
Bird watching*	1,141,454	463.3	236.3	236.3
Cycling and mountain biking	1,509,946	402.0	205.0	205.0
ATV and snowmobile	647,120	46.7	46.7	23.8
Cross-country skiing and snowshoeing	485,340	326.1	326.1	166.3
TOTAL		**2,984.4**	**1,722.2**	**1,522.0**

+ Due to the uncertainty related to what proportion of recreation days are spent no further than 20 km from the Greenbelt actually occur in the Greenbelt, three scenarios were developed. See Section 5.4.1 for a description of these scenarios.

* Note that our estimate for the value of bird watching in the Greenbelt exceeds the total expenditures for bird watching for Ontario ($176M) as reported in the Nature Survey. Our value is derived from the Nature Survey's reported average value of a birding day ($11 per day). We adjusted this value to remove transportation, food, and accommodation costs to capture only expenditures associated with "local" activities. Removing these expenditures and adjusting for inflation from 2012 to 2015 resulted in a value of roughly $3.60 per birding day. We then applied this to the estimated number of birding days in the Greenbelt. Rather than deconstructing the total Ontario expenditure estimate, we chose to build up the Greenbelt value from the Nature Survey's reported value per day to be consistent with the approach used for the other recreational values.

[55] Ontario-specific expenditure estimates were employed to the greatest extent possible. Where necessary due to lack of Ontario-specific data, average values for Canada were used.

[56] Expenditures associated with transportation, accommodation and food were excluded because of the focus in particular on costs associated undertaking the activities near home as opposed to away from home.

6.6.2 Support for Plant Cultivation

To estimate the value of the services provided by wild pollinators in the Greenbelt, the value of crops grown in the area was adjusted to account for the portion of production that is dependent on wild pollinators. The average value of crops was obtained from two sources and amalgamated as necessary into groups of crops:[57] Statistics Canada's *Fruit and Vegetable Survey*;[58] and the *Ontario Tender Fruit Producers' Marketing Board's Annual Report*.[59] The average value per hectare was then multiplied by the area (ha) of the Greenbelt dedicated to the respective crop type to derive an annual estimate of the total value of agriculture production, by crop type, for the Greenbelt. A dependency factor was then applied to these total annual values to account for the portion of the production that relies on wild pollinators. The dependency factors were obtained from the INVEST database.[60] The database contains factors by crop type that identify the percent of value derived from wild pollinators. Table 23 contains the results of the valuation of pollination services. As the dependency factors demonstrate, some crops are highly dependent on wild pollinators (e.g. fruit), while others are less dependent. Soybean production accounts for the biggest portion of the total value provided by wild pollinators, followed by pasture/forage (which are characterized by a low dependency factor, but a high value per hectare) and then orchards (which are characterized by a high dependency factor). The total value of the pollination services provided by the Greenbelt is estimated to be $48.06 M per year. [61]

Table 23: Support for Plant Cultivation Values Provided by the Wild Pollinators of the Greenbelt

Crop Type	Average Crop Value ($/ha)	Area of Crop in the GB (ha)	Annual Value of Crop in GB ($)	Dependency Factor	Value of Wild Pollination ($ Million)
Beans	1,497	122	182,368	0.05	<0.01
Berries	11,884	25	296,807	0.65	0.19
Canola	1,192	1,069	1,274,819	0.25	0.32
Orchards	4,922	2,556	12,578,312	0.65	8.18
Pasture/forage	972	181,808	176,673,561	0.05	8.83
Soybeans	1,535	70,879	108,798,499	0.25	27.20
Other vegetables	4,328	2,289	9,905,184	0.10	0.99
Vineyards	4,134	6,292	26,012,317	0.09	2.34
TOTAL		**265,039**	**335,721,867**		**48.06**

[57] For example, the different types of berries (strawberries, blueberries, etc.) were combined to form the "berry" group of crops.
[58] "Fruits and Vegetables Survey," Statistics Canada, last modified October 2, 2015, http://www.statcan.gc.ca/eng/survey/agriculture/3407.
[59] "Ontario Tender Fruit Produce Marketing Board: Annual Reports," Ontario Tender Fruit, accessed October 4, 2016, http://www.ontariotenderfruit.ca/annualreport.php.
[60] "InVEST: Integrated Valuation of Ecosystem Services and Tradeoffs."
[61] It should be noted that there is a growing body of literature examining the value of crop production provided by pollinators. This literature highlights the limitations with using dependency factors for quantifying the support for Plant Cultivation. These estimates should be considered an upper-bound since it doesn't factor in management options to compensate for the pollinator losses.

6.6.3 Existence and Bequest

> The existence value of the Greenbelt was estimated at $301.03 M per year for Households.

As noted in Section 5.4.3, these values are difficult to disaggregate to a level of detail appropriate for the Greenbelt system of accounts. Thus, they are valued holistically using a function transfer approach for the terrestrial landscape. The willingness to pay function estimated for the retention of rural and agricultural land in eastern Canada was applied to the Greenbelt context.[62] The willingness to pay per household was estimated at $100.09 (inflated to $2015) and was multiplied by the total number of households in the Greenbelt and its 20 km buffer. The existence value was estimated at $301.03 M per year.

6.6.4 Extractive Uses (excluding hunting)

Extractive uses include the harvest of edibles and wildflowers, harvest of maple sap, grazing of livestock, and hunting. The valuation of each account is discussed below. For the harvest of edibles and wildflowers, parallels were drawn from the valuation of non-timber forest products (NTFPs). In Canada, the value of NTFPs was estimated at approximately $1 B or approximately $4.29 per ha per year.[63] The forested landscape of the Greenbelt covers 182,674 ha yielding an adjusted 2015 value of $1.03 M per year ($783,671 per year*1.3092).

Statistics Canada maintains a database of the number of maple taps using the *Canada Census of Agriculture*.[64] In Ontario, on average, each maple tap yields a gross annual value of $202.37 worth of maple products. A GIS extraction for the Greenbelt revealed 33,567 maple taps yielding an adjusted 2015 valuation of $7.26 M per year ($6.79 M per year*1.0692).

[62] Bowker, J. M., & Didychuk, D. D. (1994). Estimation of The Nonmarket Benefits of Agricultural Land Retention in Eastern Canada. Agricultural and Resource Economics Review, 23(2).
[63] "Developing Nontimber Forest Products in Canada, Bulletin No. 28," Natural Resources Canada, 2003, ISSN 1496-7847, http://publications.gc.ca/collections/collection_2011/rncan-nrcan/Fo122-1-28-2003-eng.pdf.
[64] "Table 004-0009 - Census of Agriculture, maple taps, Canada and provinces, every 5 years (number)" in 2006 Agriculture Community Profiles (95-631-X), Statistics Canada, last modified February 5, 2008, http://www5.statcan.gc.ca/olc-cel/olc.action?objId=95-631-X&objType=2&lang=en&limit=0.

The value of livestock grazing was estimated by applying average unimproved pasture rental rates to the total number of unimproved hectares of pasture in the Greenbelt. The value of unimproved pasture rental rates for 2015 ranged from $20 to $60 per ha in Ontario.[65] For the purpose of this analysis, a midpoint of $40 per ha was applied for the valuation estimates. In total, there were 22,357 ha of unimproved pasture land in the Greenbelt valued at a total of $0.89 M per year.

Table 24: Value of Terrestrial Extractive Uses

Use	Valuation Unit	Value per Unit	Inflation Adjustment	Total Annual Value ($ Million)
Non-timber forest products	182,674 ha of forest cover	$4.29 per ha per year	1.3092	1.03
Maple products	33,567 taps	$202.37 per tap per year	1.0692	7.26
Livestock grazing	22,357 ha of unimproved pasture	$40 per ha per year	-	0.89
Total Terrestrial Extractive Use				**9.18**

The table above provides a summary of the terrestrial extractive use accounts in the Greenbelt. In summation, the terrestrial extractive uses were valued at $9.18 M in 2015 with the majority of the benefit derived from maple products.

6.6.5 Summary of Terrestrial Accounts

The table below provides a summary of all the terrestrial accounts that were valued for the Greenbelt. In 2015, the total estimated value of the terrestrial accounts was $2,080.47 M per year, with 83% of the total derived from the recreation accounts.

Table 25: Summary of Terrestrial Use Values

Use	Total Annual Value ($ Million)
Hiking, climbing and horseback riding	872.50
Hunting or trapping	35.60
Bird watching	236.30
Cycling and mountain biking	205.00
ATV and snowmobile	46.70
Cross-country skiing and snowshoeing	326.10
Subtotal Recreation/Tourism	**1,722.20**
Plant cultivation/pollination	48.06
Subtotal Plant Cultivation/Pollination	**48.06**
Existence and bequest	301.03
Subtotal Existence and Bequest	**301.03**
Non-timber forest products	1.03
Maple products	7.26
Livestock grazing	0.89
Subtotal Extractive Use	**9.18**
Total Terrestrial Use	**2,080.47**

[65] Personal communication. Mark Eastman (Credit Valley Conservation Authority).

7 Greenbelt Atmospheric Accounts

This chapter of the report presents the results of the valuation of the atmospheric accounts in the Greenbelt.

Table 26: Greenbelt Atmospheric Account

End-products	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary
Atmospheric Components	In-situ use	Support of human health and life	-	Household

7.1 Valuation Estimates

Value estimates for the Greenbelt atmospheric account are presented below.

7.1.1 Support for Human Health and Life

Trees impact the health and quality of human life through removing air pollution by collecting particulate matter particles, and absorbing gaseous pollutants. Indeed, studies have revealed that trees can be a viable strategy to reducing urban pollution levels.[66,67] While many studies have estimated pollution removal by trees, most studies on pollution removal do not directly link the removal with improved human health effects and associated health values.[68] The approach employed to measure the air quality benefits of Ontario's Greenbelt explicitly links the rate of pollution removal by trees with the volume of trees located in the Greenbelt and the presence of humans (measured as population density) who benefit from the improved air quality. In this way, the results better reflect the value of the Greenbelt to its beneficiaries – the people that live in it.

The approach employed to estimate the value of air filtering effects derivered by humans in the Greenbelt was modelled after a leading-edge analysis completed for the United States Department of Agriculture.[69] As is noted in the Nowak et. al. study (2015), the methodological approach can be applied in other countries to help assess the broad-scale impacts of pollution removal by trees on air quality. The regression equations presented in the Nowak report can be employed to derive estimates of human health values provided by improved air quality based on the population density of the surrounding area. Thus, as done in the Nowak study, to estimate the value of air quality resulting from the Greenbelt, the amount of air pollution (specifically, nitrogen dioxide, ozone, particulate matter (2.5), and sulphur dioxide) permanently removed by trees and forests within the Greenbelt area was estimated and its associated monetary value based on its impact on human health. According to this approach, the greater the tree cover, the higher the pollution removal; and the greater the removal and population density, the higher the value.

[66] Haider Taha, "Modeling Impacts of Increased Urban Vegetation on Ozone Air Quality in the South Coast Air Basin," Atmospheric Environment, Vol. 30 No. 20(1996), p.3423-3430.
[67] David J. Nowak, Kevin L. Civerolo, Trivikrama S. Rao, Gopal Sistla, Christopher J. Luley, & Daniel E. Crane, "A Modeling Study of the Impact of Urban Trees on Ozone," Atmospheric Environment, Vol. 34(2000), p.1610-1613.
[68] David J. Nowak, Satoshi Hirabayashi, Allison Bodine & Eric Greenfield, "Tree and Forest Effects on Air Quality and Human Health in the United States," Environmental Pollution, Vol. 193(2015), p.119-129.
[69] Ibid.

The health impacts and monetary value of the change in pollutant concentration were derived taking into consideration the population density of the area in and surrounding the Greenbelt (the population densities for each Census Subdivision that is connected to the Greenbelt). Valuation estimates were calculated using functions that estimate healthcare expenses (i.e. cost of illness and willingness-to-pay to avoid illness), productivity losses associated with specific adverse health events, and the value of a statistical life in the case of mortality. These estimates were converted into a dollar per tonne of change in pollution and assigned to the change in pollution resulting from the presence of trees in the Greenbelt, accounting for the number of people that benefit from the reduced pollution. According to Nowak et.al. (2015), this approach results in the best available and comprehensive estimates of the value to pollution removal by trees to human health.

The table below presents estimates of the value derived by humans from the air quality services provided by the trees of the Greenbelt.

Table 27: Value of Support for Human Life and Health Provided by Clean Air from the Greenbelt

Pollutant	Value ($ Million)
Nitrogen dioxide (NO_2)	0.12
Ozone	6.73
Particulate matter (2.5)	11.54
Sulphur dioxide (SO_2)	0.02
TOTAL	**18.41**

Figure 7 depicts support for human health values which vary spatially based on the combined effect of where people are located (i.e. where residents experience health benefits) and the density of tree canopy.

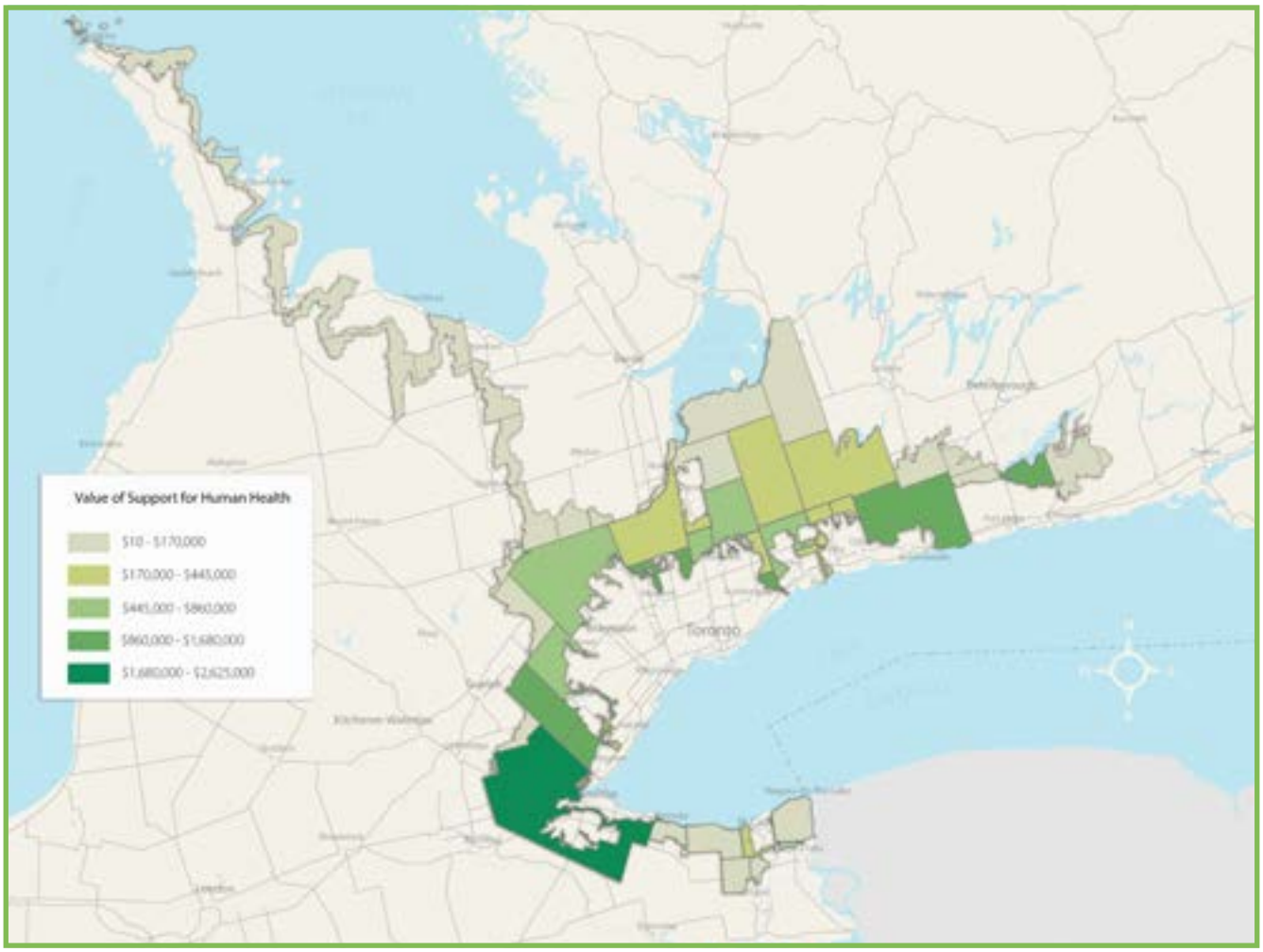

Figure 7: Support for Human Health Values within the Greenbelt by Census Subdivision

8 Carbon Storage and Sequestration

The Greenbelt plays an important role in greenhouse gas sequestration (the rate at which carbon is captured) and carbon storage (a cumulative measure of previous sequestration). In the David Suzuki Foundation 2008 study, the annual value of carbon stored in the Greenbelt (i.e. from forests, wetlands, and agricultural soils) was estimated at $366.7 M in 2005 dollars and the annual sequestration service was estimated at $10.7 M. According to the David Suzuki Foundation 2012 study, the estimated value of carbon storage and sequestration from wetlands in Ontario's Greenbelt was $348.4 M or carbon storage and $1.22 M for annual sequestration. For agriculture, the value of carbon storage and annual sequestration was $2.08 B and value was $2.4 M[70], respectively.

For the current study, carbon storage and sequestration estimates are provided for each of forest, agricultural soils, and wetland. In the case for forest carbon, a detailed carbon budget modelling process was used to estimate storage and sequestration providing an advancement over previous forest carbon estimates for the Greenbelt. Similar methodological advancements were not feasible for agricultural soils and wetland carbon, so for these land cover types the David Suzuki Foundation (2012) approach was followed with the average rates of storage and sequestration per ha applied to the new land cover area estimates determined in this study.

8.1 Forest Carbon

In this study, the Carbon Budget Model of the Canadian Forest Service Sector (CBM-CFS3) was used to estimate the value of the carbon stored (the stock of carbon) and sequestered (the flow of carbon) in the Greenbelt.[71] The Carbon Budget Model is a stand and landscape-level modelling framework that simulates the dynamics of all forest carbon stocks (e.g. carbon contained in aboveground biomass, belowground biomass, litter, dead wood and soil). To employ CBM-CFS3, SOLRIS data for the forested area of the Greenbelt was used. The forested area was allocated to different tree species and age classes based on data from the national forestry inventory.[72] The detailed forestry data permitted the development of a Greenbelt-specific CBM-CFS3 model, which was used to generate estimates of carbon stock in the Greenbelt disaggregated between aboveground biomass, belowground biomass, and tree part (e.g. root, foliage, stem, and branch). Environment Canada's social cost of greenhouse gas emission estimate for 2016 ($42.87 per tonne CO_2e) was applied to the total volume of carbon stored in the Greenbelt's forests to estimate the monetary contribution to carbon storage.[73] The table below contains the results of the carbon budget modelling for forests in the Greenbelt.

Table 28: Forest Carbon Storage in the Greenbelt

Total Carbon Stored (tonnes)	29,603,010
Value of Carbon Storage ($ Billions)	$4.65

[70] Ray Tomalty, Carbon in the Bank: Ontario's Greenbelt and its Role in Mitigating Climate Change (Vancouver: David Suzuki Foundation, 2012).
[71] "Carbon Budget Model," Natural Resources Canada, last modified June 23, 2016, http://www.nrcan.gc.ca/forests/climate-change/carbon-accounting/13107.
[72] "Canada's National Forest Inventory," accessed October 4, 2016, https://nfi.nfis.org/en/.
[73] "Technical Update to Environment and Climate Change Canada's Social Cost of Greenhouse as Estimates," Environment and Climate Change Canada, last modified Mach 10, 2016, http://www.ec.gc.ca/cc/default.asp?lang=En&n=BE705779-1.

The CBM-CFS3 model was also used to derive estimates of the rate of annual carbon sequestration for the Greenbelt. In this regard, the model accounts for the rate of carbon obtained by the forest taking into consideration the rate of release of carbon from the forest as a result of decay. Estimating carbon sequestration from the Greenbelt required obtaining growth yield curves by species for the species present in the Greenbelt.[74] These were input into the CBM-CFS3 model to derive annual estimates of carbon sequestration for the Greenbelt over a 40-year period. Environment Canada's social cost of greenhouse gas emission estimates for the period between 2016 ($42.87 per tonne CO_2e) and 2055 ($78.79 per tonne $CO2_e$) were applied to the total volume of carbon stored in the Greenbelt to estimate annual monetary contributions to carbon sequestration of the Greenbelt. [75]

Table 29: Carbon Sequestration in the Greenbelt

Average Annual Carbon Sequestered (tonnes)	204,149
Average Annual Value of Carbon Sequestered ($ Millions)	$44.94

Figure 8 demonstrates the trend in carbon sequestration over time in relation to Environment Canada's social cost of greenhouse gas emission values over the same time period. Over the 40-year period between 2016 and 2054, the annual sequestration rate of the Greenbelt declines, which is in contrast to the increasing trend in the social cost of greenhouse gas emissions.

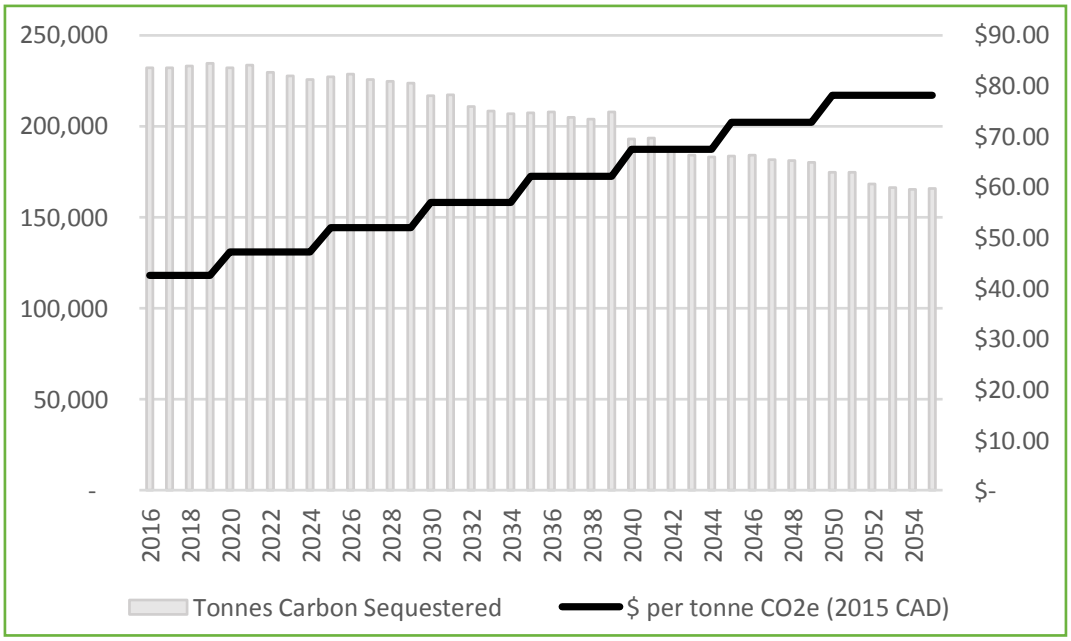

Figure 8: Annual Carbon Sequestered in the Greenbelt in Relation to Environment Canada's Social Cost of Greenhouse Gas Emissions

[74] Daniel Marina & Sean C. Thomas, "An Analysis of the Modeling and Inventory Support Tool: Yield Curves Vary with Forest Ecosystem Classification," The Forestry Chronicle, Vol. 88, No. 2(2012), p.147-153.
[75] "Technical Update to Environment and Climate Change Canada's Social Cost of Greenhouse as Estimates."

The decline in annual carbon sequestration in the Greenbelt is the result of an aging forest ecosystem characterised by increasing decay resulting in higher carbon release, which is greater than the increase in carbon sequestration resulting from new growth. The figure below demonstrates the trend in the annual value of carbon sequestration in the Greenbelt (the product of the annual volume of carbon sequestered and the value of that carbon – shown in the Figure 8). Despite the overall decline in the annual amount of carbon sequestered in the Greenbelt, the total value of sequestration increases due to the increasing price per tonne of carbon.[76]

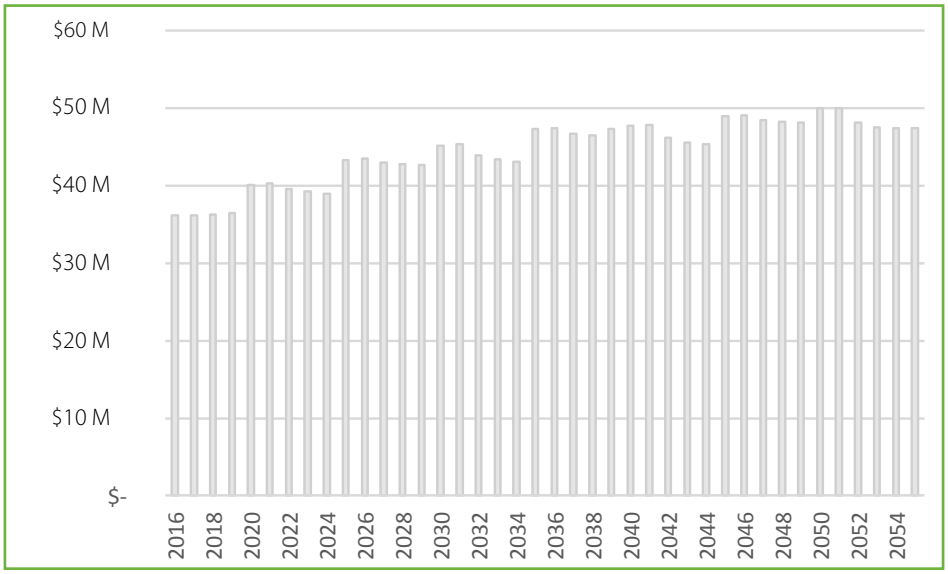

Figure 9: Value of Annual Carbon Sequestration in the Greenbelt

8.2 Agricultural Carbon

As part of the carbon equation, agricultural land plays a critical role in the sequestration and storage of carbon in agricultural soils. Similar to forests, as crops grow, the plants absorb CO_2 from the atmosphere. Some of the carbon is stored in the plant material and released back into the atmosphere after harvest, while some carbon is stored in the soil. [77] The amount of carbon sequestered and stored in agricultural soils depends on a complex combination of factors, including soil type, tillage practices, and the crop types grown.[78]

Using an average estimate of 80 tonnes of carbon per ha (as was used by the David Suzuki Foundation (2012)), carbon storage in agricultural soils within the Greenbelt can be approximated as 34.38 M tonnes (or 126.06 M tonnes of CO_2e). Using Environment Canada's social cost of carbon, the value of carbon stored by agricultural land can be estimated to $5.40 B.

The David Suzuki Foundation (2012) study notes that the high variance in agricultural practices across the Greenbelt and the lack of detailed studies examining carbon sequestration in southern Ontario make it difficult to accurately assess the rate of sequestration.[79] However, the 2012 study assumed that idle land, orchards and hedge rows sequestered 0.5 tonnes of carbon per year. Using this approach carbon sequestration from

[76] These trends assume that there is no unforeseen disturbance (human and nature in cause) to the projected forest-growth trajectory of the Greenbelt.
[77] Tomalty, Carbon in the Bank: Ontario's Greenbelt and its Role in Mitigating Climate Change.
[78] Tristram O. West & Gregg Marland, "A Synthesis of Carbon Sequestration, Carbon Emissions, and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States," Agriculture, Ecosystems & Environment, Vol. 91 No. 1(2002), p.217-232.
[79] Tomalty, Carbon in the Bank: Ontario's Greenbelt and its Role in Mitigating Climate Change.

agricultural land within the Greenbelt is approximated to 19,516 tonnes of carbon per year (or 71,560 tonnes of CO_2e per year).[80] After applying the social cost of carbon, the value of carbon sequestered on these lands can be conservatively estimated at $3.07 M per year.

8.3 Wetland Carbon

Wetlands are also an important component of the Greenbelt's ability to store and sequester carbon. Since many wetlands are considered anaerobic (i. e. without oxygen), they tend to have slower rates of decomposition relative to drier ecosystems.[81] As a result the carbon stored in wetlands is released back into the atmosphere at a much slower rate. As noted in Section 8.1, this release of carbon to the atmosphere is the main reason why the net rate of sequestration for forest carbon slowly declines over time.

The David Suzuki Foundation (2012) utilized Canada's Soil Carbon Database to estimate that the 94,014 ha of wetlands in the Greenbelt store 6.7 M tonnes of carbon.[82] The revised wetland area estimated in this report was 100,063 ha. Some of this difference is attributed to the true gains and losses of wetland area (summarized in Table 5), as well as from improved data between 2001 and 2011. Without further details on how the Soil Carbon Database was used in the previous assessment, the 2012 carbon storage estimate is adjusted proportionally to the total area of wetlands. This results in a total of 7.1 M tonnes of carbon (or 26.1 M tonnes CO_2e), for a carbon storage value of $1.12 B.

Using the estimated rate of carbon sequestration for wetlands (0.25 tonnes of carbon per ha)[83], total carbon sequestered by wetlands in the Greenbelt can be approximated to 25,016 tonnes per year (or 91,725 tonnes of CO_2e per year). Using Environment Canada's social cost of carbon, the value of carbon sequestration provided by wetlands can be estimated as $3.93 M per year.

Table 30: Summary of the Value of Ecosystem Services in the Greenbelt

Land Cover	Carbon Storage Value ($ BIllion)	Carbon Sequestration Value ($ Million per year)
Forest	4.65	44.94
Agricultural Soils	5.40	3.07
Wetlands	1.12	3.93
Total	**11.17**	**51.94**

[80] This is based on applying the sequestration rate of 0.5 tonnes of carbon per year to 7,826 ha of hedge rows; 2,556 ha of orchards; 6,292 ha of vineyards and 22,357 ha of unimproved pasture.
[81] Tomalty, Carbon in the Bank: Ontario's Greenbelt and its Role in Mitigating Climate Change.
[82] Ibid.
[83] Ibid.

Summary of Greenbelt Accounts

9

Table 31 provides a summary of the value of the final services derived from the natural capital of the Greenbelt. Aquatic and terrestrial uses, and in particular recreation activities, in the Greenbelt accounted for the majority of the value of ecosystem services in 2015. The table demonstrates that terrestrial values accounted for 65% of the total estimated value. Overall, the Greenbelt accounts were valued at $3.2 B per year. This equates to $1,061 per household for the population living within a 20 km radius of the Greenbelt boundary and approximately 1.0% of the Toronto area's 2015 gross domestic product ($3,197.82 M / $353,322.73 M*100).[84]

Table 31: Summary of the Value of Ecosystem Services in the Greenbelt

Use	Total Annual Value ($ Million)
Aquatic Use	
Non-motorized water and beach	162.30
Angling	179.50
Waterfowl hunting	41.40
Subtotal Recreation/Tourism	**383.20**
Subtotal Protection of Human Property	**224.35**
Subtotal Existence, Bequest, Aesthetics	**124.15**
Crop irrigation	7.63
Livestock	1.06
Water supply (households)	358.55
Subtotal Extractive Use	**367.24**
Total Aquatic Use	**1,098.94**
Terrestrial Use	
Hiking, climbing and horseback riding	872.50
Hunting or trapping	35.60
Bird watching	236.30
Cycling and mountain biking	205.00
ATV and snowmobile	46.70
Cross-country skiing and snowshoeing	326.10
Subtotal Recreation/Tourism	**1,722.20**
Subtotal Plant Cultivation/Pollination	**48.06**
Subtotal Existence, Bequest, Aesthetics	**301.03**
Non-timber forest products	1.03
Maple products	7.26
Livestock grazing	0.89
Subtotal Extractive Use	**9.18**
Total Terrestrial Use	**2,080.47**
Atmospheric Use	
Clean air	18.41
Total Atmospheric Use	**18.41**
Total Valuation (All Uses)	**3,197.82**

[84] "Economic Indicators March 2016," City of Toronto, March 2016, http://www.investtoronto.ca/InvestAssets/PDF/Reports/Toronto_Economic_Indicators.pdf.

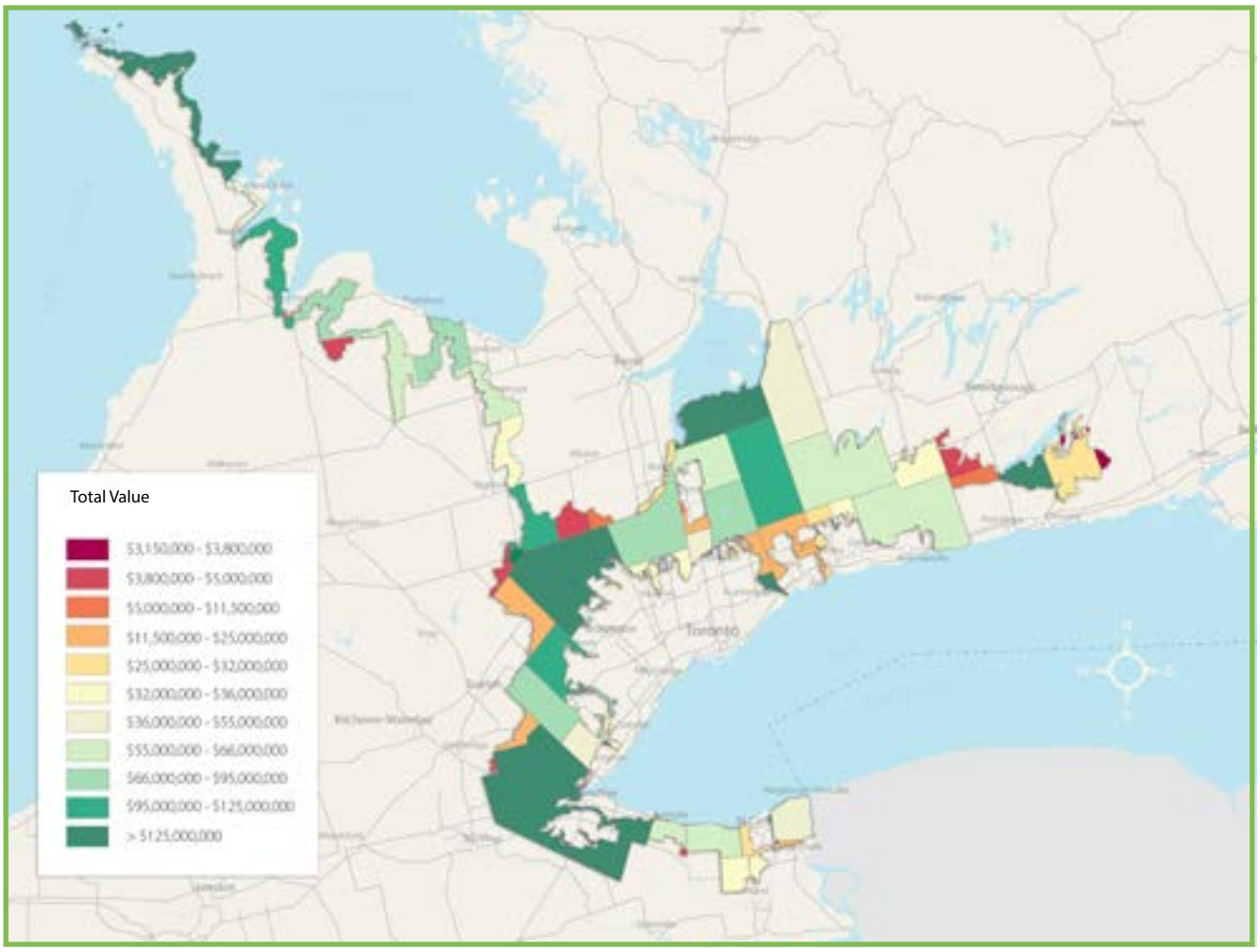

Figure 10: Total Annual Value of Ecosystem Service Flows to Beneficiaries by Census Subdivision

As is evident from the results reported in Sections 5 and 6, some of the assessments lend themselves well to mapping (e.g. protection of human property) while others (e.g. recreation) were estimated at the Greenbelt level. For those accounts that had less spatial resolution, values were disaggregated and allocated spatially to census subdivisions. The disaggregation process relied on the relative proportion of natural capital in each census subdivision. For instance, waterbased values were allocated by the relative proportion of water permit maximum volumes. For recreation, we used the relative number of trailheads, access points, boat launches, and campgrounds to distribute the values spatially. While this process is not ideal, it allowed for an approximation of the spatial distribution of values across the Greenbelt.

Recreation values drive the higher values in the Bruce Peninsula and Southern Georgian Bay areas. Areas surrounding Hamilton are also highly valued as a result of the large population surrounded by a relatively high density of forest and wetland cover. These conditions drive the values associated with recreation, support for human health, and the protection of human property. Similar conditions are driving values in the northern portion of the Region of Peel (i.e. Caledon). Aside from a few smaller census subdivisions, which contain lower proportions of natural capital, most subdivisions of the Greenbelt are generating more than $55 M per year.

> "Most subdivisions of the Greenbelt are generating more than $55 M per year

In addition to the $3.2 B in annual final services generated by the Greenbelt, the value of carbon storage is $11 B with carbon sequestration worth $52 M per year. It is clear that Ontario's Greenbelt provides significant annual value to Ontario residents. The spatial nature of the flow of final services from the Greenbelt, as well as the spatial distribution of the beneficiaries, was an important consideration in estimating the value of the final services of the Greenbelt's natural capital. Indeed, much of the value associated with final services is based on the proximity of the Greenbelt to those who derive benefit from it – the people living in and around the Greenbelt. Over 9 million people living within the Greater Golden Horseshoe are located within 20 km of the Greenbelt and thus derive value from recreational opportunities, protection of property, extractive uses and existence/bequest benefits. The important link between the location of the Greenbelt and the flow and distribution of services to beneficiaries was made explicit in a number of Greenbelt accounts, including, for example:

- Health benefits from clean air, which depend upon a correlation between people who directly benefit from the cleaner air and the quantity of forest providing the cleaner air.
- Flood control benefits, which factor in the population and economic activity in the surrounding area to account for those benefiting from this service.
- Benefits derived from water use (e.g. clean drinking water, agricultural irrigation, etc.), which are based on the volume of water consumed by different users.
- Recreation benefits, which are based on the number of recreational users living within a 20 km radius of the Greenbelt.

The value estimates demonstrate the substantial contribution of recreation to the total value of the services derived from the natural capital of the Greenbelt. In fact, recreation is how most people engage with and therefore, benefit from Ontario's Greenbelt. The clean air, clean water, intact forests that are associated with the Greenbelt all contribute to the value that participants derive from recreating in it. Willingness to pay studies examine the factors that contribute to the value people place on various activities. In the context of recreation, proximity as well as the condition of the area (e.g. trails being maintained, easily accessible and not congested) are also important contributing factors. The high expenditure estimates derived for participants recreating in the Greenbelt indicate a high willingness to pay for this particular location.

As is often the case with studies of this nature, not all services have been valued in the current study. For this reason, the overall estimate of the value derived from the services of the Greenbelt should be considered conservative in nature. While the results are focused on the values that were quantifiable, the accounts that were not valued are also key components. An important advantage of the approach taken in this study is that a reasonably comprehensive set of final ecosystem service flows have been defined. The result is a clearly outlined list of items that have not been accounted for (see the unshaded rows of the table of accounts in Sections 5 and 6). These unquantified values could be the focus of future research and data gathering efforts.


3

10 Conclusions

The Greenbelt holds a wealth of important natural and environmental features from which the people living and working in and around it benefit greatly. From the clean air and water that sustains human life to the natural beauty of the landscape that provides recreational opportunities, the Greenbelt is uniquely positioned to provide and preserve a high quality rural and agricultural landscape for the benefit of millions of Ontarians. This assessment draws on leading edge analytical approaches and improved data availability to provide the best available, estimates of the value of services provided by the natural capital of Ontario's Greenbelt.

Despite these advances, there is scope for further enhancements. A separate compendium document to this report provides a summary of the various ways in which the framework and valuation outlined here can be enhanced to better support a system of natural capital accounting at regional or municipal levels. In so doing, it provides recommendations to improve results and respond to existing gaps.

The framework and results described in this report can be used as a tool to quantify and track the values of natural capital within a defined region, such as the Greenbelt. Using the conceptual framework can help conservation authorities, municipalities, and other environmental organizations take better account of their natural capital assets and measure their value in terms of the flow of final services they provide to people. While some of the valuation approaches might need to be adjusted for a smaller-scale assessment, some jurisdictions could have more detailed data (e.g. recreation usage, or property location data) allowing the estimation of accounts at more disaggregated levels.

The value derived by people is dependent on the condition of the natural capital. By regularly monitoring the quantity, quality, and value (based on human usage) of natural capital, municipalities can better protect and manage it. For instance, increased value is derived through proper maintenance of trails and knowing the value derived by humans from trail use can help justify expenditure on trail maintenance. Similarly, knowing which wetlands are providing flood protection, can help justify alternative development strategies. The box on the next page describes a number of ways in which natural capital assessment and valuation can be used by policy and land-use decision makers.

Implications for Decision Makers

The natural capital accounting framework employed in this study is useful for decision makers concerned with policy, planning and land use decisions. Specifically, for a defined geographic area, the framework can be used to:

- Educate policy makers and the public on the economic importance of protecting and enhancing natural capital and green infrastructure.
- Establish the baseline conditions for a defined geographic area from which alternative policy, planning and land use changes can be assessed.
- Inform policy decisions related to resource development and conservation:
    - Identify the natural capital accounts of high value to beneficiaries and that perhaps should be protected from aggregate extraction or highway infrastructure if potential conflict arises.
    - Identify the natural capital accounts of low value to beneficiaries that may deliver multiple gains through investment in restoration or enhancement. For example, forest restoration that would serve conservation goals while improving air quality and providing additional recreational opportunities.
- Incorporate the value derived from natural capital with cost-benefit analysis to inform and help prioritize investments in the protection, conservation, restoration or enhancement of natural capital.
- Assign value to the natural capital that can be integrated into traditional economic and/or economic accounting frameworks (e.g. gross domestic product) to consider the magnitude of, or any implications to, the value derived from natural capital on a level playing field with market-based goods and services.
- Provide an additional tool to assess the success of conservation, preservation, protection or restoration initiatives on the value derived from natural capital.

Ontario's Greenbelt provides substantial value to the people that live in and around it. Using updated approaches and the best available data, the value derived from the natural capital of the Greenbelt was estimated at $3.2 B per year, or $1,061 per household for the population living within a 20 km radius of the Greenbelt boundary. The proximity of the Greenbelt to a high portion of the population of Ontario (69%), results in a unique opportunity for many people to derive benefit from this provincial recreational and agricultural hub. Indeed, 90% of Ontarians agree that the Greenbelt is one of the most important contributors to the future of the province. The $3.2 B in value derived from the Greenbelt per year is a testament to its importance to current and future generations, and reinforces the need to take careful stock of natural capital assets ensuring they are properly managed to enhance the services they provide in perpetuity.

> “ Value delivered from the natural capital of the Greenbelt was estimated at $1,061 per household for the population living within a 20 km radius of the Greenbelt boundary

References

"Agricultural Water Use in Canada, 2010 – Updated." Statistics Canada, Catalogue no. 16-402-X. Last modified November 17, 2015. http://www5.statcan.gc.ca/olc-cel/olc.action?objId=95-631-X&objType=2&lang=en&limit=0.

"Annual Crop Inventory, 2009-2015." Government of Canada. Ottawa: Agriculture and Agri-Food Canada, 2013. http://open.canada.ca/data/en/dataset/ba2645d5-4458-414d-b196-6303ac06c1c9.

"Canada's National Forest Inventory." Accessed October 4, 2016. https://nfi.nfis.org/en/.

"Fruits and Vegetables Survey, 2015." Statistics Canada. Survey no. 3407. Last modified October 2, 2015, http://www.statcan.gc.ca/eng/survey/agriculture/3407.

National Ecosystem Services Classification System (NESCS): Framework Design and Policy Application. EPA-800-R-15-002. Washington: United States Environmental Protection Agency, 2015.

"Southern Ontario Land Resource Information System (SOLRIS)." Ontario Ministry of Natural Resources and Forestry. Version 2.0: Data Specifications, 2015. https://www.sse.gov.on.ca/sites/MNR-PublicDocs/EN/CMID/SOLRIS%20v2.0%20-%20Data%20Specifications%20Version.pdf

"Table 004-0009 - Census of Agriculture, maple taps, Canada and provinces, every 5 years (number)." Statistics Canada. 2006 Agriculture Community Profiles (95-631-X). Last modified February 5, 2008. http://www5.statcan.gc.ca/olc-cel/olc.action?objId=95-631-.

"Technical Update to Environment and Climate Change Canada's Social Cost of Greenhouse as Estimates." Environment and Climate Change Canada. Cat. No: En14-202/2016E-PDF. Last modified Mach 10, 2016. http://www.ec.gc.ca/cc/default.asp?lang=En&n=BE705779-1.

"Wetlands." Land Information Ontario. Government of Ontario. Last modified August 19, 2016. https://www.ontario.ca/page/land-information-ontario.

Bateman, Ian J., Matthew Cole, Philip Cooper, Stavros Georgiou, David Hadley & Gregory L. Poe. "On Visible Choice Sets and Scope Sensitivity." Environmental Economics and Management, 47 no. 1(2004): 71-93.

Bowker, Michael J. & D.D. Didychuk. "Estimation of The Nonmarket Benefits of Agricultural Land Retention in Eastern Canada." Agricultural and Resource Economics Review, 23 no. 2(1994): 218-225.

Boyd, James & Spencer Banzhaf. "What are Ecosystem Services? The Need for Standardized Environmental Accounting Units." Ecological Economics, 63 no. 2(2007): 616-626.

Boyd, James, Paul Ringold, Alan Krupnick, Robert Johnston, Matthew Weber & Kim Hall. "Ecosystem Services Indicators: Improving the Linkage between Biophysical and Economic Analyses." 2015 (RFF DP 15-40).

Boyle, Kevin J, William H. Desvousges, F. Reed Johnson & Sara P. Hudson. "An Investigation of Part-Whole Bias in Contingent Valuation Studies." Journal of Environmental Economics and Management, 27 no. 1(1994): 64-83.

Brander, Luke, Roy Brouwer & Alfred Wagtendonk. "Economic Valuation of Regulating Services provided by Wetlands in Agricultural Landscapes: A Meta-analysis." Ecological Engineering, 56(2013): 89-96.

Carson, Richard T. & Robert C. Mitchell. "Sequencing and Nesting in Contingent Valuation Surveys." Journal of Environmental Economics and Management, 28 no.2(1995): 155-173.

Dupont, Diane P. & Steven Renzetti. "Good to the Last Drop? An Assessment of Canadian Water Value Estimates." Canadian Water Resources, 33 no. 4(2008): 369-380.

Federal, Provincial, and Territorial Governments of Canada. "2012 Canadian Nature Survey: Awareness, Participation, and Expenditures in Nature-based Recreation, Conservation, and Subsistence Activities." Ottawa: Canadian Councils of Resource Ministers, 2014.

Fisher, Brendan, R. Kerry Turner & Paul Morling. "Defining and Classifying Ecosystem Services for Decision Making." Ecological Economics, 68(2009): 643-653.

Fisher, Brendan, et al. "Ecosystem Services and Economic Theory: Integration for Policy-Relevant Research." Ecological Applications, 18 no. 8(2008): 2050-2067.

Johnston, Robert J., John Rolfe, Randall J. Rosenberger & Roy Brouwer. Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners. London: Springer, 2015.
Haines-Young, Roy & Marion Potschin. Common International Classification of Ecosystem Services (CICES, Version 4.1). Copenhagen: European Environmental Agency, 2012.

Landers, Dixon H. & Amanda M. Nahlik. Final ecosystem goods and services classification system (FEGS-CS). Washington: United States Environmental Protection Agency, 2013.

Marina, Daniel & Sean C. Thomas. "An Analysis of the Modeling and Inventory Support Tool: Yield Curves Vary with Forest Ecosystem Classification." The Forestry Chronicle 88, no. 2(2012): 147-153.

Nowak, David J., Kevin L. Civerolo, Trivikrama S. Rao, Gopal Sistla, Christopher J. Luley, & Daniel E. Crane. "A Modeling Study of the Impact of Urban Trees on Ozone." Atmospheric Environment, 34(2000): 1610-1613.

Nowak, David J., Satoshi Hirabayashi, Allison Bodine & Eric Greenfield. "Tree and Forest Effects on Air Quality and Human Health in the United States." Environmental Pollution, 193(2015):119-129.

Smith, Pete, et al. UK National Ecosystem Assessment: Technical Report. Cambridge: UNEP-WCMC, 2011.

Taha, Haider. "Modeling Impacts of Increased Urban Vegetation on Ozone Air Quality in the South Coast Air Basin." Atmospheric Environment, 30 no. 20(1996): 3423-3430.

Tomalty, Ray. Carbon in the Bank: Ontario's Greenbelt and its Role in Mitigating Climate Change. Vancouver: David Suzuki Foundation, 2012.

Wallace, Ken J. "Classification of Ecosystem Services: Problems and Solutions." Biological Conservation, 139 no. 3-4(2007): 235-246.

West, Tristram O. & Gregg Marland. "A Synthesis of Carbon Sequestration, Carbon Emissions, and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States." Agriculture, Ecosystems & Environment, 91 no. 1(2002): 217-232.

Appendix 1: Detailed Land Cover Summary

Table 1: Land Cover Breakdown for Greenbelt

Detailed SOLRIS Cover Type	Condensed Land Cover Type	Area (ha)
Undifferentiated	Agriculture	263,621
Bog	Wetland	50
Built Up Area - Impervious	Developed	26,434
Built Up Area - Pervious	Developed	9,342
Coniferous Forest	Forest	35,643
Deciduous Forest	Forest	75,266
Extraction - Aggregate	Developed	4,758
Extraction – Peat/topsoil	Developed	182
Fen	Wetland	182
Forest	Forest	6,439
Hedge Row	Hedge Row	7,826
Marsh	Wetland	10,822
Mixed Forest	Forest	44,306
Open Alvar	Alvar	180
Open Beach/Bar	Beach	4
Open Cliff and Talus	Cliff and Talus	20
Open Tallgrass Prairies	Grassland	26
Open Water	Water	8,597
Plantation	Forest	21,020
Shrub Alvar	Alvar	26
Tallgrass Savannah	Grassland	26
Tallgrass Woodland	Grassland	27
Thicket Swamp	Wetlands	9,985
Tilled	Agriculture	166,144
Transportation	Developed	25,320
Treed Alvar	Alvar	6
Treed Cliff and Talus	Cliff and Talus	124
Treed Swamp	Wetland	79,024
TOTAL		**795,399**

Appendix 2: Detailed Land Cover Maps

Figure 1: Zoomed in Land Cover in the Northwest Portion of Ontario's Greenbelt

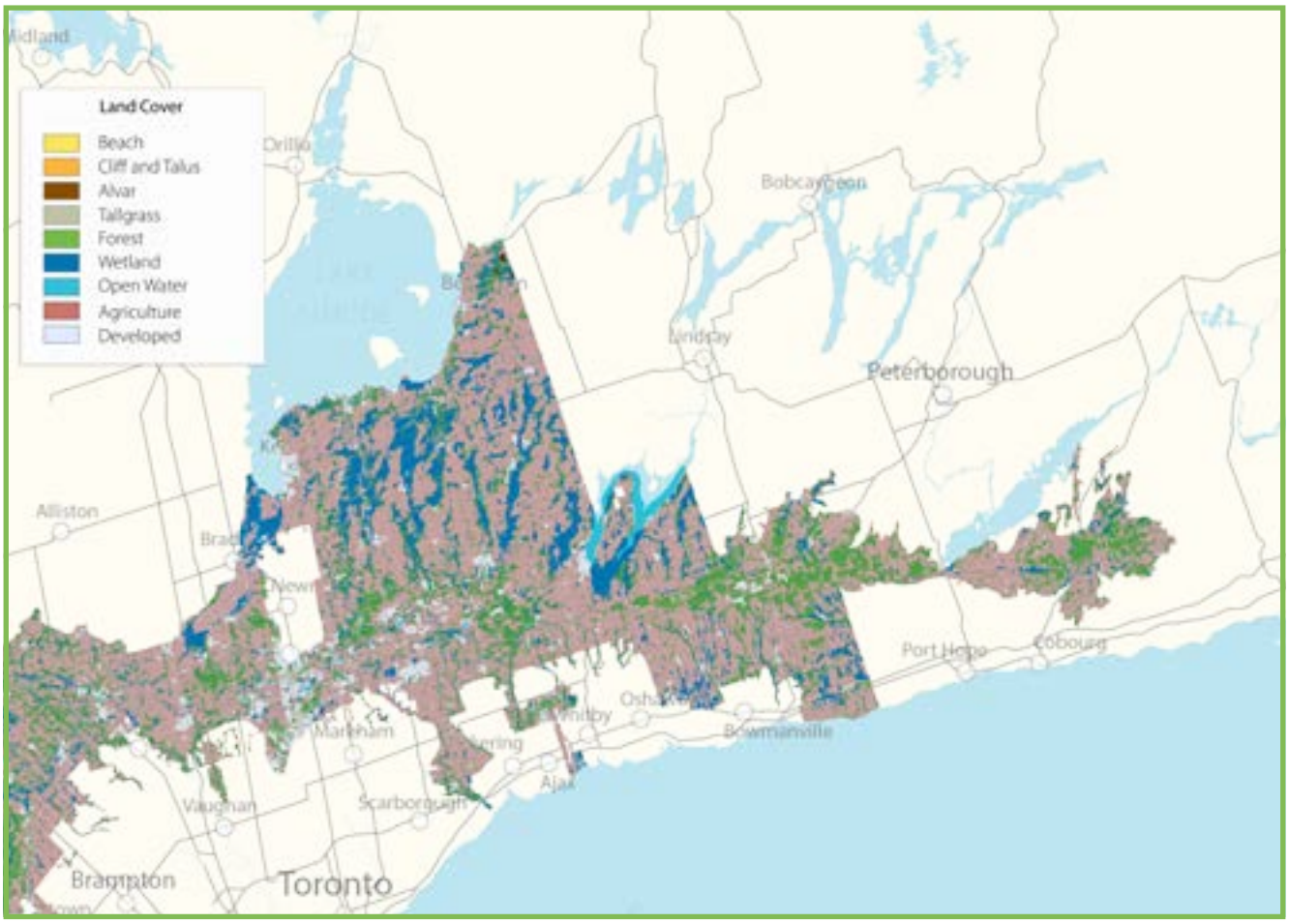

Figure 2: Zoomed in Land Cover in the Eastern Portion of Ontario's Greenbelt

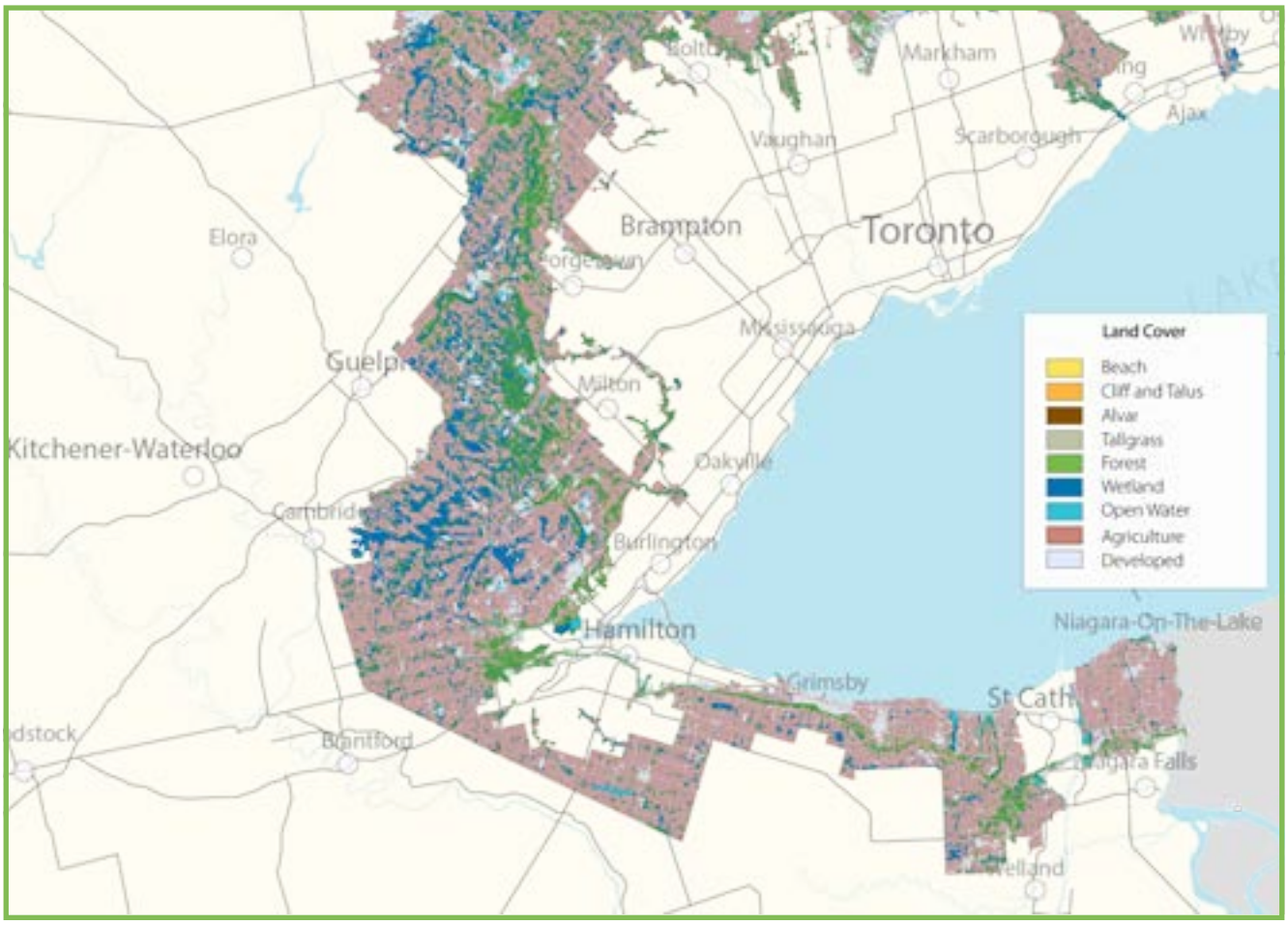

Figure 3: Zoomed in Land Cover in the Southern Portion of Ontario's Greenbelt

Appendix 3: Detailed Account Listing

Account	Environmental subclass	End-products	End-products subclass	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary	Beneficiary subclass	Market / Non-market
T1	Forest	Flora	Wood fibre	Extractive use	Raw material for transformation	Timber	Industry	Forestry and logging	Market
T2	Forest	Flora	Wood fibre	Extractive use	Energy	Fire wood	Household	Homes using wood based heating	Market
T3	Forest	Flora	Mushrooms / wild berries / nuts	Extractive use	Other extractive use		Household	People who care	Non-market
T4	Forest	Flora	Sugar maple trees	Extractive use	Raw material for transformation	Maple sap	Industry	Food manufacturing	Market
T5	Forest	Fauna	Mammals	Non-use	Existence and bequest		Household	People who care	Non-market
T6	Forest	Fauna	Mammals	Extractive use	Recreation/ tourism	Hunting	Household	Hunters	Non-market
T7	Forest	Fauna	Birds	Non-use	Recreation/ tourism	Bird watching	Household	Birdwatchers	Non-market
T8	Forest	Fauna	Birds	Non-use	Existence and bequest		Household	People who care	Non-market
T9	Forest	Composite end-products	Forest landscape	In-situ use	Recreation/ tourism	Fall colour viewing	Industry	Tourism operators	Non-market
T10	Forest	Composite end-products	Forest landscape	In-situ use	Aesthetic appreciation	Scenic views	Household		Non-market
T11	Forest	Composite end-products	Forest landscape	In-situ use	Recreation/ tourism	Hiking	Household	Hikers	Non-market
T12	Forest	Composite end-products	Presence of forest	Non-use	Existence and bequest		Household	People who care	Non-market
T13	Forest	Composite end-products	Forest ecosystem	In-situ use	Information, science, education		Government	Public schools; universities	Non-market
T14	Forest	Composite end-products	Regulation of extreme events	In-situ use	Protection of human health and life	Avoided drowning	Household		Non-market
T15	Forest	Composite end-products	Regulation of extreme events	In-situ use	Protection of human property	Avoided crop damage	Industry	Agricultural crop producers	Market

T16	Forest	Composite end-products	Regulation of extreme events	In-situ use	Protection of human property	Avoided damage to vehicles	Household	Vehicles in flood areas	Market
T17	Forest	Composite end-products	Regulation of extreme events	In-situ use	Protection of human property	Avoided residential damages	Household	Home owners in flood areas	Market
T18	Forest	Composite end-products	Regulation of extreme events	In-situ use	Protection of human property	Avoided ICI damages	Industry	Industries with property in flood areas	Market
T19	Grasslands	Flora	Wild flowers	In-situ use	Aesthetic appreciation	Wild flower viewing	Household		Non-market
T20	Grasslands	Flora	Wild flowers	Extractive use	Distribution to other users	Harvest of non-cultivated flowers and seeds	Household		Market
T21	Grasslands	Flora	Pasture (e.g. prairie tall grass)	Extractive use	Support for animal cultivation	Grazing of livestock	Industry	Livestock producers	Market
T22	Grasslands	Flora	Wild berries	Extractive use	Other extractive use	Edible berries	Household		Non-market
T23	Grasslands	Fauna	Birds	In-situ use	Recreation/ tourism	Bird watching	Household	Birdwatchers	Non-market
T24	Grasslands	Fauna	Birds	Non-use	Existence and bequest		Household	People who care	Non-market
T25	Grasslands	Fauna	Mammals	Extractive use	Recreation/ tourism	Hunting	Household	Hunters	Non-market
T26	Grasslands	Fauna	Pollinators	In-situ use	Support for plant cultivation	Improved crop productivity	Industry	Agricultural crop producers	Market
T27	Grasslands	Fauna	Mammals	Non-use	Existence and bequest		Household	People who care	Non-market
T28	Grasslands	Composite end-products	Regulation of extreme events	In-situ use	Protection of human health and life	Avoided drowning	Household		Non-market
T29	Grasslands	Composite end-products	Regulation of extreme events	In-situ use	Protection of human property	Avoided crop damage	Industry	Agricultural crop producers	Market
T30	Grasslands	Composite end-products	Regulation of extreme events	In-situ use	Protection of human property	Avoided damage to vehicles	Household	Vehicles in flood areas	Market

Account	Environmental subclass	End-products	End-products subclass	Use / Non-use	Use / Non-use subclass	Detailed Use / Non-use	Beneficiary	Beneficiary subclass	Market / Non-market
T31	Grasslands	Composite end-products	Regulation of extreme events	In-situ use	Protection of human property	Avoided residential damages	Household	Home owners in flood areas	Market
T32	Grasslands	Composite end-products	Regulation of extreme events	In-situ use	Protection of human property	Avoided ICI damages	Industry	Industries with property in flood areas	Market
T33	Grasslands	Composite end-products	Grassland landscape	In-situ use	Aesthetic appreciation	Scenic views	Household		Non-market
T34	Grasslands	Composite end-products	Grassland landscape	In-situ use	Recreation/ tourism	Hiking	Household	Hikers	Non-market
T35	Grasslands	Composite end-products	Presence of Grasslands	Non-use	Existence and bequest		Household	People who care	Non-market
T36	Grasslands	Composite end-products	Grassland ecosystem	In-situ use	Information, science, education		Government	Public schools; universities	Non-market
T37	Agroecosystems	Soil	Suitable soil conditions	In-situ use	Support of plant cultivation	Crop productivity	Industry	Agricultural crop producers	Market
T38	Agroecosystems	Fauna	Birds	In-situ use	Recreation/ tourism	Bird watching	Household	Birdwatchers	Non-market
T39	Agroecosystems	Fauna	Pollinators	In-situ use	Support of plant cultivation	Crop productivity	Industry	Agricultural crop producers	Market
T40	Agroecosystems	Composite end-products	Agricultural landscape	In-situ use	Aesthetic appreciation	Rural countryside viewing	Household		Non-market
T41	Agroecosystems	Composite end-products	Agricultural landscape	Non-use	Existence and bequest	Cultural value	Household		Non-market
T42	Agroecosystems	Composite end-products	Agricultural landscape	In-situ use	Recreation/ tourism	Agri-tourism	Household		Non-market
T43	Alvar	Flora	Wild flowers	In-situ use	Aesthetic appreciation	Wild flower viewing	Household		Non-market
T44	Alvar	Flora	Wild berries	Extractive use	Other extractive use	Edible berries	Household		Non-market
T45	Alvar	Fauna	Birds	In-situ use	Recreation/ tourism	Bird watching	Household	Birdwatchers	Non-market
T46	Alvar	Fauna	Birds	Non-use	Existence and bequest		Household	People who care	Non-market

T47	Alvar	Fauna	Mammals	Extractive use	Recreation/ tourism	Hunting	Household	Hunters	Non-market
T48	Alvar	Fauna	Pollinators	In-situ use	Support for plant cultivation	Improved crop productivity	Industry	Agricultural crop producers	Market
T49	Alvar	Fauna	Mammals	Non-use	Existence and bequest		Household	People who care	Non-market
T50	Alvar	Composite end-products	Alvar landscape	In-situ use	Aesthetic appreciation	Scenic views	Household		Non-market
T51	Alvar	Composite end-products	Alvar landscape	In-situ use	Recreation/ tourism	Hiking	Household	Hikers	Non-market
T52	Alvar	Composite end-products	Presence of Alvar	Non-use	Existence and bequest		Household	People who care	Non-market
T53	Alvar	Composite end-products	Alvar ecosystem	In-situ use	Information, science, education		Government	Public schools; universities	Non-market
T54	Barren rock and sand	Other abiotic components	Sandy beach	In-situ use	Recreation/ tourism	Beach activities	Household	Beach users	Non-market
T55	Barren rock and sand	Other abiotic components	Rocky beach or shoreline	In-situ use	Recreation/ tourism	Hiking	Household	Hikers	Non-market
T56	Forest	Composite end-products	Forest landscape	In-situ use	Recreation/ tourism	Biking	Household	Cyclists	Non-market
T57	Grasslands	Composite end-products	Grassland landscape	In-situ use	Recreation/ tourism	Biking	Household	Cyclists	Non-market
T58	Forest	Composite end-products	Forest landscape	In-situ use	Recreation/ tourism	Skiing	Household	Skiers	Non-market
T59	Grasslands	Composite end-products	Grassland landscape	In-situ use	Recreation/ tourism	Skiing	Household	Skiers	Non-market
T60	Agroecosystems	Composite end-products	Agricultural landscape	In-situ use	Recreation/ tourism	Skiing	Household	Skiers	Non-market
T61	Forest	Composite end-products	Forest landscape	In-situ use	Recreation/ tourism	ATV / Snowmobile	Household	ATV / Snowmobile users	Non-market
T62	Grasslands	Composite end-products	Grassland landscape	In-situ use	Recreation/ tourism	ATV / Snowmobile	Household	ATV / Snowmobile users	Non-market
T63	Agroecosystems	Composite end-products	Agricultural landscape	In-situ use	Recreation/ tourism	ATV / Snowmobile	Household	ATV / Snowmobile users	Non-market

Appendix 4: Comparison of Results with 2008 Study

The following provide an itemized comparison of specific results between the current assessment and the 2008 assessment:

- **The value of flood control provided by wetlands**: The 2008 study used an average value of flood control per ha and the total area of wetlands within the Greenbelt to derive a flood control value of $380 M per year (2005 CAD). In comparison, the current study estimated the protection of human property from wetlands to be worth $224 M. This approach used a meta-regression function, and detailed data on the wetlands within the Greenbelt, to assign a value to each individual wetland, adjusting the value based on the size of the wetland, proximity to substitute wetland sites, surrounding population that could benefit from flood control, and economic activity within the area. The result is an estimate that varies spatially based on the potential beneficiaries.

- **Air quality**: The 2008 study used a tool called CITYgreen to derive estimates for air quality. This tool no longer appears to be available, and was largely parametrized for an urban setting. The current study relied on updated and refined information generated by researchers involved with the CITYgreen tool. The 2008 air quality value was estimated at $69 M (2005 CAD) per year, while this study estimated a value of $18 M per year. The difference in value is the result of the following factors that were accounted for in the current study:

    - The current study makes use of more refined data. Since a forest's ability to remove pollution is a function of the amount of leaf area and the quantity of pollutants in the surrounding air, the amount of pollution removed is highly dependent on the spatial context.

    - Since the portions of the Greenbelt that tend to be more heavily forested also tend to be further from the densely populated areas, those trees tend to be exposed to lower concentrations of air pollutants.

    - The final service is a function of the change in air quality that results in health benefits to residents living in the area. Therefore, the more people that reside in areas where there is a significant density of tree cover, the greater the health benefits.

- **Recreation**: Compared to the last study, this study captures the value resulting from a broader spectrum of activities including birding (which has a relatively low value per day, but high days of participation per year), hunting (which is characterized by a relatively low number of days of participation per year, but high value per day), and angling. The 2008 study estimated recreation and aesthetics to be $95 M (2005 CAD) per year. Using more detailed recreation data and focusing in particular on the beneficiaries of the recreation opportunities provided by the Greenbelt (the approximately 7 million adults that live within a 20 km radius of the Greenbelt boundary), the current study attributes significantly more recreation value to the Greenbelt, roughly over $2 B per year.

- **Pollination**: The current study makes use of detailed spatially-oriented agricultural crop data that was not available when the previous study was undertaken. The use of this more recent data allowed the value estimates to be directly linked to the contribution of pollination to crop production, by crop type. In the 2008 study, pollination was valued at $360 M (2005 CAD) per year, while this study estimates pollination at $48 M. The large difference between the estimates is attributed to increased data resolution which allowed for a much more specific valuation estimate. Moreover, the current study only considered the value derived from wild pollinators.

- **Carbon**: The 2008 study used the CITYgreen tool to estimate carbon storage and sequestration, by applying storage and sequestration "multipliers" to the area of forest cover in the Greenbelt. Utilizing advances in forest data information, this study established a finer detailed mapping of the forest cover, delineating tree species and approximate age. This allowed for a more sophisticated carbon modelling approach that accounted for the net fluxes of carbon over time as the forest ages. Differences in the carbon sequestration values between the two studies can be attributed to a combination of the following factors:

- **Increases in the social cost of carbon**: The 2008 study used $52 per tonne of carbon (or $14 per tonne of CO_2e) in 2005 CAD. Updated prices used in this study range from $42 to $78 per tonne of CO_2e in 2015 CAD.

    - **Differences in the estimate of carbon storage**: The 2008 study assumed an average of 220 tonnes per ha of forest. With the detailed carbon model output, this study determined carbon storage based on forest type and age. Across the Greenbelt the average storage capacity estimated in the current study was 162 tonnes per ha.

    - **Differences in the effective rate of sequestration**: The 2008 study assumed a constant rate of 0.75 tonnes per ha. Using the detailed carbon modelling employed in the current study, average sequestration for the Greenbelt was estimated to begin at 0.77 tonnes per ha, and decline overtime to 0.55 tonnes per ha as the forest ages.