

Baxter Creek Watershed Alliance and Ecosystem Services Valuation

Includes:

Final Report

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Introduction

The Baxter Creek Watershed Alliance (BCWA) is a local organization in Cavan-Monaghan, Ontario area working to improve the health and sustainability of the Baxter Creek subwatershed area. The BCWA partners with municipal government and other local stakeholders to help improve watershed health from a community-centered approach. With increased developmental pressures in the Millbrook area, there is a renewed urgency to develop comprehensive frameworks for identifying ecosystem values provided by the subwatershed.

A knowledge gap that has been identified for this project relates to Ecosystem Services Valuation (ESV) and its relevance for subwatershed planning in the Baxter Creek area. An ESV framework is valuable from the perspective of municipal development, since it helps to identify the monetary value of certain ecosystem services provided by the watershed. However, the ESV framework is a complicated and evolving process, and it is not entirely clear how ESV might be implemented in the Baxter Creek subwatershed planning context. This report seeks to fill this knowledge gap for the BCWA.

The purpose of this report is to evaluate the potential of Ecosystem Service Valuation (ESV) for the Baxter Creek subwatershed to enhance watershed management strategies in alignment with Ontario's provincial guidelines. The report will conclude with a series of recommendations for BCWA's next steps, based on our findings.

ESV Overview

Ecosystem services are commonly recognized as benefits that humans receive from ecological systems. While it might seem obvious that humans rely on and benefit from the natural world and what it provides, identifying ecosystem services is becoming increasingly relevant as development threatens the stability of those services we receive. Generally, services that humans receive from the natural world can be either natural (water purification, for example) or cultural (recreation, for example) (DeLoyde & Mabee, 2023). Troy and Bagstad (2009) identify four categories of ecosystem services:

1. Provisioning services. This category covers those goods that humans receive from ecosystems. This could include food, water, and fuels.
2. Regulating services. This category covers ecosystem functions that in turn benefit human society. This could include climate, disease regulation, and flood regulation.
3. Cultural services. This category covers human activities that rely on natural systems. This could include recreation, aesthetics, and education.
4. Supporting services. This category covers any ecosystem functions that are needed for the production of other ecosystem services. This could include soil formation, waste treatment, and nutrient cycles.

DeLoyde and Mabee (2023) suggest that we should use a systems thinking approach to conceptualizing ecosystem services, since those services (and the ecosystem functions they emerge from) exist within the complexity of ecosystems. So, when conceptualizing the ecosystem services we receive from the landscape, we should consider the interconnections of different ecosystems and how one service can be affected by others. For example, flood

regulation affects our ability to enjoy an ecosystem recreationally; or, soil nutrient cycles affect our ability to grow food.

Increasingly, there is a recognition that assigning monetary value to ecosystem services can be an effective way to account for their importance for environmental decision makers and land use planners (Troy & Bagstad, 2009). Because ecosystem services are not exchanged through the market, their value can easily go unacknowledged and become negative externalities (Miller, 2018). So, ecosystem services valuation (ESV) allows us to conduct cost-benefit analyses between the value of development and the value of ecosystem services (Troy & Bagstad, 2009), and to make apparent the hidden costs and/or benefits of land use change (Miller, 2018). Valuation of ecosystem services will be a particularly valuable tool, then, in the context of development pressures and the challenges that will accompany climate change. In this context, it becomes increasingly important to have tools that help us protect ecosystem processes that are essential to human health and livelihood (Mitchell et al., 2021).

Ecosystem services valuation could also be a useful tool to help us reconsider what types of land we consider for development. Mitchell et al. (2021) observed that areas of marginal value to agriculture and development are the ones that tend to be designated for protection. While this might seem economically convenient, ecosystem services valuation could give us a better understanding of what lands provide the most economic value through services (Mitchell et al., 2021). Ecosystem services valuation could help us better the relative value of different sites (DeLoyde & Mabee, 2023). This is also true for urban areas, where a greater demand is put on ecosystem services, likely making them more economically valuable (Mitchell et al., 2021).

As this points to, values are very context-dependent. There is, of course, a cultural component to what we choose (consciously or not) to value, and so ESV values will always reflect that cultural bias; but these values are also physically rooted in what services the ecosystem can supply and what quantity of those services is demanded by human society (Miller, 2018). Aziz and Cappellen (2019) use the terminology of potential and realized services to describe this supply and demand. Mitchell et al. (2021) use the terms ecosystem capacity and human demand in these discussions. Whatever terminology is used, it's important to make sure our ESV models take both into account. Understanding the relationship between supply and demand in any given community will help us better understand priorities for protection (Mitchell et al., 2021). Only focusing on an ecosystem's capacity can lead to inefficient protection of land and services (Mitchell et al., 2021).

Clearly, ESV helps to correct some of the oversights present in business-as-usual development and land use changes; however, like any tool, it comes with its own limitations and complications. It is rare to account for the full value of all ecosystem services at a site. The amount of time and resources that would be required is not practical in most conservation contexts (Troy & Bagstad, 2009). Even if it were possible to do a full inventory of an ecosystem, the fact remains that not all ecosystem values can be quantified with a money value; this is especially true for the intrinsic values of a natural area (Miller, 2018; Troy & Bagstad, 2009). So, we shouldn't assume that the entire value of an ecosystem can be reduced to a dollar amount, and we should acknowledge this limitation when using ESV. Ultimately, ESV is too simplistic to give a full account of the value of an ecosystem – but it would be worse to not account for

ecosystem services, at all, which would only lead to further land degradation (DeLoyde & Mabee, 2023). ESV can be a useful tool (in a much broader toolkit) in its place.

Given that it is usually not practical to take a full inventory of an ecosystem's value, Troy and Bagstad (2009) recommend the common practice of value transfer (or benefits transfer), which allows us to use ESV information from similar contexts to estimate the value of the ecosystem of interest. In practice, this would mean scanning the literature for valuation studies where the resource type (eg. forest, wetland, grassland, etc.) and context is the same (eg. natural or cultural) (Troy & Bagstad, 2009). Before any ESV scan such as this is conducted, it's important to know the context of your own project, and your reasons pursuing ESV. Your own approach should cohere with the valuation studies being used for value transfer (E. Miller, personal communication, March 12, 2025). If dated valuation studies are used, this can easily be overcome by applying inflation rates to make the values relevant today (Troy & Bagstad, 2009). However, if an ESV study is based on out-of-date methods, then using that study in a value-transfer approach might not be so easily accommodated.

There are some standard approaches to valuation of ecosystem services. DeLoyde and Mabee (2023) recommend using the Millennium Ecosystem Assessment, since it is a widely accepted framework for ESV. Because the Millennium Ecosystem Assessment provides a standardized framework, this also makes comparisons between different studies possible and reliable. These valuations often result in a single value for an area as dollars per hectare per year; however, many valuations often break this down further by ecosystem types (Troy & Bagstad, 2009). Additionally, a valuation can consider the combined value of all services within a single ecosystem, or individual services can be valued on their own (Miller, 2018). Miller

(2018) suggests bundling ecosystem services into one value if the land use change will completely replace the ecosystem (eg. a meadow being turned into a parking lot); and he suggests considering services individually if some services will be retained or are comparable after the land use change.

Troy and Bagstad (2009) define five ways of valuing ecosystem services:

1. Contingent valuation. For this method, a survey is conducted where citizens are asked about their willingness to pay for ecosystem services.
2. Hedonic pricing. This method involves statistical analysis of housing prices in the area to estimate the value of services.
3. Travel cost. This method involves an evaluation of how much citizens are willing to pay to travel to a resource.
4. Factor income. For this method, the value of a natural resource is analyzed based on its use in producing another resource.
5. Replacement Cost. For this method, a value is found by considering the cost of creating a replacement to the lost natural function.

These approaches will be expanded upon below.

ESV can be a powerful tool for advocating for conservation efforts in the context of development and land use changes. In particular, it can be an important part of a communication strategy to help advocate for these issues. They also give quantitative values to help make a case for sustainability in land use changes (E. Miller, personal communication, March 12, 2025). However, there is no obligation to take part in these sorts of valuation studies, and it is usually conservationists who are interested in pursuing this work. So, there

may be some value in engaging with ecological economists to better integrate these valuation studies (E. Miller, personal communication, March 12, 2025).

ESV Frameworks and Models

Frameworks for valuing ecosystem services offer organized methods for calculating the various benefits that ecosystems provide. By attempting to apply valuation to services, such as climate regulation or water purification, these frameworks go beyond conventional market-based appraisals. Employing various techniques, these frameworks can be a useful tool and starting point for integrating the value that ecosystem features provide, into management and planning decisions. The frameworks listed below can be used on their own, but it is a common strategy to employ methods from multiple frameworks to best suit individual needs.

The Millennium Ecosystem Assessment (MEA) Framework

The Millennium Ecosystem Assessment was a report commissioned by the United Nations Secretary General in 2003, investigating ecological change on a global scale (The Government of Ontario, 2013). It is a widely used system that separates services into four categories.

Table 1. *Ecosystem services under the MEA categorized by use and function.*

The Millennium Ecosystem Assessment (MEA) Framework	
Provisioning Services	Goods obtained from ecosystems - food, water, timber, etc.
Regulating Services	Benefits from ecosystem processes - climate regulation, water purification, flood control, etc.
Cultural Services	Non-material benefits – recreation, education, etc.
Supporting Services	Services that maintain ecosystem function - nutrient cycling, habitat provided, etc.

The Economics of Ecosystems and Biodiversity (TEEB) Framework

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative that aims to integrate the economic value of ecosystem services into decision making and policy (TEEB, n.d.). It is a framework used globally by institutional organizations.

Table 2. Categories the TEEB framework utilizes to value ecosystem services.

The Economics of Ecosystems and Biodiversity (TEEB) Framework	
Direct use values	Agriculture, fisheries, timber, etc.
Indirect use values	Water filtration, climate regulation, etc.
Option values	Future use potential, what is being passed on
Non-use values	Cultural heritage, etc.

Total Economic Value (TEV) Framework

The total economic valuation (TEV) model is a framework that aims to capture the full spectrum of ecosystem-derived values. It goes beyond market valuation to include values that are not typically traded (Pascua et al., 2010).

Table 3. Categories the TEV framework utilizes to value ecosystem services.

Total Economic Value (TEV) Framework		
Use Values	Direct Use	Harvesting resources, tourism, etc.
	Indirect Use	Flood control, carbon sequestration, etc.
Non-Use Values	Bequest Value	Value for future generations to inherit
	Existence Value	Value people assign to nature regardless of use

Cost-Based Valuation Methods

Cost-based valuation methods are used to estimate ecosystem value based on cost savings or replacement costs (Ontario, 2013). These valuation methods do not include non-use values and are therefore easier to utilize, however, the full spectrum of provided benefits is not included.

Table 4. Cost-based methods utilized to value ecosystem services.

Cost-Based Valuation Methods	
Avoided Cost Method	Estimates costs avoided due to ecosystem services, such as flood protection from wetlands
Replacement Cost Method	Calculates the cost of replacing ecosystem functions with artificial systems
Damage Cost Avoided	Measures potential damage prevented by ecosystem services

Additional Valuation Methods

Table 5. Additional methods utilized to value ecosystem services.

Additional Valuation Methods	
Payment for Ecosystem Services (PES)	Incentive programs where beneficiaries pay for services
Biodiversity Offsets	Companies compensate for ecological damage by funding conservation elsewhere
Eco-Tourism Valuation	Assesses the economic contribution of protected areas through tourism revenue
Willingness-to-Pay Surveys	Public input is sought to assess and estimate what cost citizens are willing to pay for the ecosystem services provided
Willingness-to-Pay Surveys	Public input is sought to assess and estimate what cost citizens are willing to pay for the ecosystem services provided

Hedonic Pricing	Demand for service may be reflected in the prices people will pay for associated benefits
Travel Cost	Demand for service may require travel, with the cost being reflected by what people are willing to pay to access the service
Benefit transfer	Use valuation data from similar studies in other locations to estimate values in the subwatershed

ARIES (ARtificial Intelligence for Ecosystem Services) Framework

ARIES integrates spatial modeling, environmental data and artificial intelligence to map ecosystem services across the landscape (The Government of Ontario, 2013). The framework does not categorize services, rather it maps services based on the actual and theoretical provisions and uses. It distinguishes between the source of the service, where services are absorbed (sinks), and beneficiaries.

Due to its dynamic nature, ARIES offers unique benefits and characteristics when compared to static frameworks. ARIES is an open-source platform that integrates the Knowledge Laboratory, or k.LAB, an AI-powered modeling software (The Government of Ontario, 2013), provides accessibility and the ability to perform comprehensive modelling. ARIES also distinguishes itself by its ability to synthesize multiple thematic areas, such as ecosystem services and watershed spatial planning within a single project, outputting more comprehensive models. The integrated approach offered by ARIES provides context specific assessments of ecosystem services compared to static frameworks and methods, with high value of the framework lying in its adaptive capabilities. ARIES will adapt modelling based on the data and models availability, tracking the uncertainty of the data or modelling and adjusting based on inferences produced by its AI (The Government of Ontario, 2013). This is an incredibly

valuable feature when modelling in dynamic environments. However, it may also present a higher degree of difficulty for users due to its complexity.

ESV Applications

This section summarizes various ESV case studies findings from different southern Ontario contexts. It is designed to act as a quick reference to various ESV studies in Ontario. Information and ecosystem service values have been condensed for relevance to the Baxter Creek subwatershed context. Monetary values can be updated based on your current year's inflation rates (Troy & Bagstad, 2009).

DeLoyde and Mabee (2023) conducted a study in southern Ontario to understand the value of the four types of ecosystem services (ie. provisioning, supporting, regulating, and cultural services). Their findings are summarized below in *Tables 6 to 9*.

Table 6. Value of provisioning services by landcover type in southern Ontario. Values in 2022 Canadian dollars per hectare per year. Information adapted from DeLoyde & Mabee (2023).

Service	Landcover type	Median (\$)	Mean (\$)	Min (\$)	Max (\$)
Provision of fresh water	Environmentally sensitive areas	1,082	1,082	1,082	1,082
	Wetland	671	22,415	572	66,000
	Forest	425	7,042	0	22,862

Table 7. Value of supporting services by landcover type in southern Ontario. Values in 2022 Canadian dollars per hectare per year. Information adapted from DeLoyde & Mabee (2023).

Service	Landcover type	Median (\$)	Mean (\$)	Min (\$)	Max (\$)
Nutrient cycling	Wetland	3,044	3,398	3,044	3,748
	Forest	691	691	691	691
	Meadowlands and thickets	34	34	34	34
	Old fields	34	34	34	34
Soil formation	Environmentally sensitive areas	715	715	476	953
	Forest	24	24	24	24
	Meadowlands and thickets	8	8	8	8
	Old fields	8	8	8	8

Table 8: Value of regulating services by landcover type in southern Ontario. Values in 2022 Canadian dollars per hectare per year. Information adapted from DeLoyde & Mabee (2023).

Service	Landcover type	Median (\$)	Mean (\$)	Min (\$)	Max (\$)
Air quality (pollution)	Meadowlands and thickets	693	693	693	693
	Forest	530	623	530	1,339
	Wetland	19	19	19	19
Climate (carbon sequestration)	Environmentally sensitive areas	169	169	169	169
	Meadowlands and thickets	40	40	40	40
	Forest	37	36	1	71
	Wetland	18	18	18	18
Climate (carbon storage)	Forest	1,232	1,232	1,172	1,292
	Wetland	876	1,029	603	1,912
	Old fields	445	445	445	445
Natural hazard regulation (flood control)	Wetland	5,677	8,129	5,676	13,032
	Forest	645	516	645	903
	Old fields	8	8	8	8
Water purification and waste treatment	Wetland	3,019	3,049	151	6,387
	Forest	674	519	82	838
Water regulation	Wetland	41,495	41,495	41,495	41,495
	Forest	1,726	1,424	520	2,285

Table 9: Value of cultural services by landcover type in southern Ontario. Values in 2022 Canadian dollars per hectare per year. Information adapted from DeLoyde & Mabee (2023).

Service	Landcover type	Median (\$)	Mean (\$)	Min (\$)	Max (\$)
Aesthetic and inspiration	Wetland	2,569	4,465	165	13,486
	Forest	1,101	1,101	470	1,731
Cultural heritage value	Wetland	3,084	5,593	65	12,722
	Forest	321	317	308	324
	Old fields	194	194	194	194
	Tilled land	125	125	125	125
Recreation, tourism, and lifestyle	Wetland	1,731	4,278	156	13,302
	Forest	470	787	248	2,328
	Tilled land	235	235	235	235
	Environmentally sensitive area	10	10	10	10
Spiritual and religious values	Old fields	194	194	194	194

Troy and Bagstad's (2009) study of southern Ontario sought to estimate an average value of total ecosystem services by landcover type. Information and valuations presented below (*Table 10*) have been summarized for relevance to the Baxter Creek subwatershed context.

Table 10: Total ecosystem service value for southern Ontario by landcover type. Values are in 2008 Canadian dollars per hectare per year. Information was adapted from Troy and Bagstad (2009).

Land cover type	2008 CA\$ / ha / yr
Agriculture	291
Grassland / pasture / hayfield	353
Forest: non-urban	4,443
Forest: adjacent to stream	4,552
Urban herbaceous greenspace	43,788
Open water: river	55,553
Open water: urban / suburban river	236,392
Wetlands: non-urban, non-coastal	15,171
Wetlands: urban / suburban	161,420

Aziz and Cappellen's (2019) study sought to find the realized value of ecosystem services in southern Ontario. Recall that the realized value of ecosystem services is the value of services actually used by human society (drawing from the full, potential value of all services the ecosystem is capable of providing). Their findings are summarized below in *Table 11*.

Table 11: Table shows the total realized value of ecosystem services by land use type. Values are in 2017 Canadian dollars per hectare per year. Ecosystem services considered include water supply, water quality, carbon sequestration, carbon storage, flood regulation, and recreation. Information summarized from Aziz and Cappellen (2019).

Land Use	Total (2017 CA\$ / ha / year)
Forest	4,310
Wetland	9,995
Open water	10,045
Agriculture	575

The Lake Simcoe Region Conservation Authority (2017) conducted a study to help them understand the non-market values of ecosystem services within the Lake Simcoe watershed. They were able to break down the valuations by municipality, and *Table 12* (below) summarizes the findings for The City of Kawartha Lakes. The southern part of this municipality's border is quite close to Millbrook, Ontario, and so these values may provide some relevance to the Baxter Creek subwatershed (at least as a local comparison). Findings have been condensed for relevance to the Baxter Creek subwatershed context.

Table 12: Table showing the total value of ecosystem services in The City of Kawartha Lakes by ELC community type. Values are in 2016 Canadian dollars per hectare per year. Services considered are recreation, water supply, pollination, gas regulation (clean air, disturbance avoidance, carbon sequestration, and habitat and refugia. Information adapted from Lake Simcoe Conservation Authority (2017).

ELC community type	Total (2016 CAN \$ / ha / year)
Coniferous forest	4,972
Deciduous forest	5,010
Mixed forest	4,991
Cultural meadow	4,941
Cultural plantation	4,991
Cultural thicket	4,941
Cultural woodland	724
Meadow marsh	8,534
Shallow marsh	6,011
Coniferous swamp	6,695
Deciduous swamp	6,915
Mixed swamp	6,230
Thicket swamp	5,963
Open water	4,278
Intensive agriculture	370
Non-intensive agriculture	559

Using a non-market-based approach, the Simcoe Lake Region Conservation Authority (2010) applied values to the ecosystem services by land cover type to assess the watershed's overall values. The *Black River Subwatershed Plan* (Simcoe Lake Region Conservation Authority, 2010) describes a further breakdown of these values (*Table 13*). If using the benefit transfer approach, these values could be used to guide valuation within the Baxter Creek subwatershed as the subwatersheds have similar features.

Table 13: Monetary values applied to ecosystem services that are classified by landcover type for the Black River subwatershed. Dollar year is not specified, so assume publication year (2010). Information adapted from Lake Simcoe Conservation Authority (2010).

Land Cover Type	Value per hectare (\$/ha/yr)
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Forests	4 798
Grasslands	2 727
Wetlands	11 172
Water	1 428
Cropland	529
Hedgerows/Cultural Woodland	1 453
Pasture	1 479
Urban Parks	824

Provincial and Municipal Guidelines

Provincial policies, such as those outlined in the Provincial Policy Statement (2024) and various land use plans, set the overarching framework for land use planning in Ontario.

Ecosystem services valuation should align with these policies to ensure that it supports the broader provincial goals related to environmental protection and sustainable development.

Municipal planning guidelines, such as the Township of Cavan-Monaghan's Official Plan (2021), apply provincial policies to local contexts. Incorporating these guidelines ensures that ecosystem services valuation is relevant to local priorities and considerations.

The following are policies, objectives and guidelines set out in Provincial and Municipal plans which can be used to identify areas for valuation and guide in applying levels of importance for ecological features within the subwatershed. This section is not exhaustive, and as such, is intended as an overview.

Provincial Policy Statement

The Provincial Policy Statement (PPS) is Ontario's key land use planning document, setting out provincial policies on matters of land use that directly impact economic, environmental and social wellbeing (The Government of Ontario, 2024). It mandates that municipalities ensure their planning decisions are consistent with its policies. When guiding ecosystem service valuation within the Baxter Creek subwatershed, the PPS can be used to identify areas of environmental significance and inform decisions that protect or enhance valuable ecosystem services.

Policies within the PPS (2024) place significance on natural heritage systems and water resources. The policy highlights maintaining linkages and identifying areas of significance, including forests and wetlands.

4.1 Natural Heritage

1. Natural features and areas shall be protected for the long term.
2. The diversity and connectivity of natural features in an area and the long-term ecological function and biodiversity of natural heritage systems should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and groundwater features.
4. Development and site alteration shall not be permitted in:
 - a) significant wetlands in Ecoregions 5E, 6E and 7E1; and
 - b) significant coastal wetlands.
5. Development and site alteration shall not be permitted in:
 - b) significant woodlands in Ecoregions 6E and 7E
 - c) significant valleylands in Ecoregions 6E and 7E
 - d) significant wildlife habitat;

4.2 Water

1. Planning authorities shall protect, improve or restore the quality and quantity of water by:
(see Appendix I)

2. Development and site alteration shall be restricted in or near sensitive surface water features and sensitive ground water features such that these features and their related hydrologic functions will be protected, improved or restored, which may require mitigative measures and/or alternative development approaches.

Oak Ridges Moraine Conservation Plan

Through the Oak Ridges Moraine Conservation Act (2001), the province of Ontario developed the Oak Ridges Moraine Conservation Plan (2017) (ORMCP) to provide direction for protecting ecological and hydrological features of the moraine from the intense pressures of development and resource extraction. The Oak Ridges Moraine Conservation Act (2001) directs municipalities to conform their Official Plans to the ORMCP (2017) and ensure that their planning decisions conform to the Plan. The plan emphasizes the value of hydrological functions, natural heritage features and linkages.

The ORMCP (2017) sets out several objectives:

- a) protecting the ecological and hydrological integrity of the Oak Ridges Moraine Area;
- b) ensuring that only land and resource uses that maintain, improve or restore the ecological and hydrological functions of the Oak Ridges Moraine Area are permitted;
- c) maintaining, improving or restoring all the elements that contribute to the ecological and hydrological functions of the Oak Ridges Moraine Area, including the quality and quantity of its water and its other resources

Furthermore, the ORMCP (2017) divides the Oak Ridges Moraine into four land use designations used to guide development decisions. These designations may be useful in identifying areas of significance within the Baxter Creek subwatershed.

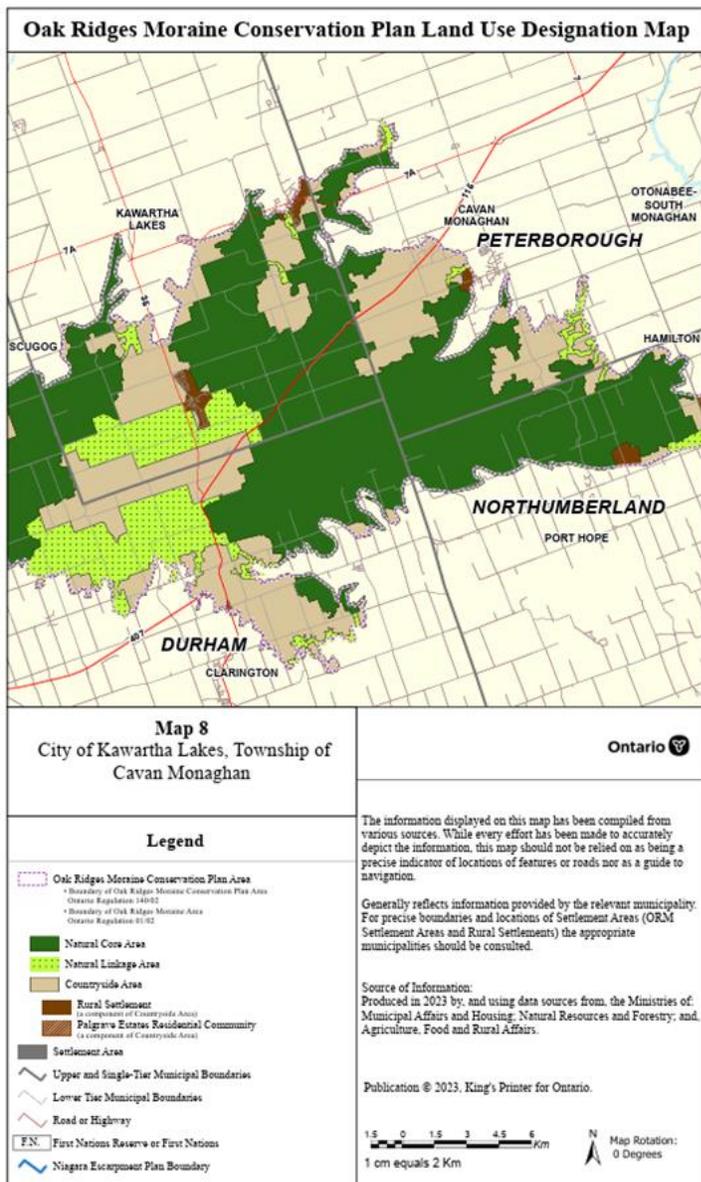


Figure 1. A map produced by the Government of Ontario (2023) outlining the land use designations in the Oak Ridges Moraine as per the Oak Ridges Moraine Conservation Plan.

Natural Core Areas - Protecting these lands is vital to maintaining the integrity of the Moraine, as they contain the greatest concentrations of key natural heritage features.

Natural Linkage Areas - These areas protect natural and open space linkages between the Natural Core Areas and along rivers and streams.

Countryside Areas - These areas are intended to provide an agricultural and rural transition and buffer between the Natural Core, Linkage Areas, and Settlement Areas. They protect prime agricultural areas and natural features.

Settlement Areas – These areas include existing communities; urban uses and development as set out in official municipal plans are permitted.

The Greenbelt Plan

The Greenbelt includes lands within the Oak Ridges Moraine and builds upon the ecological protection provided by the Oak Ridges Moraine Conservation Plan (2017). The Province of Ontario created the Greenbelt Act (2005) to mitigate the potential impacts of developmental pressures on the Greater Golden Horseshoe area. The Greenbelt Plan (2017) was created under the Act and defines the Greenbelt as a broad band of permanently protected land which provides permanent protection to the natural heritage and water resource systems that sustain ecological and human health. As with the other plans, it places value on hydrological systems and natural heritage features. The southeastern portion of the Baxter Creek subwatershed lies within the Greenbelt Act area and is, therefore, subject to the plan's policies.

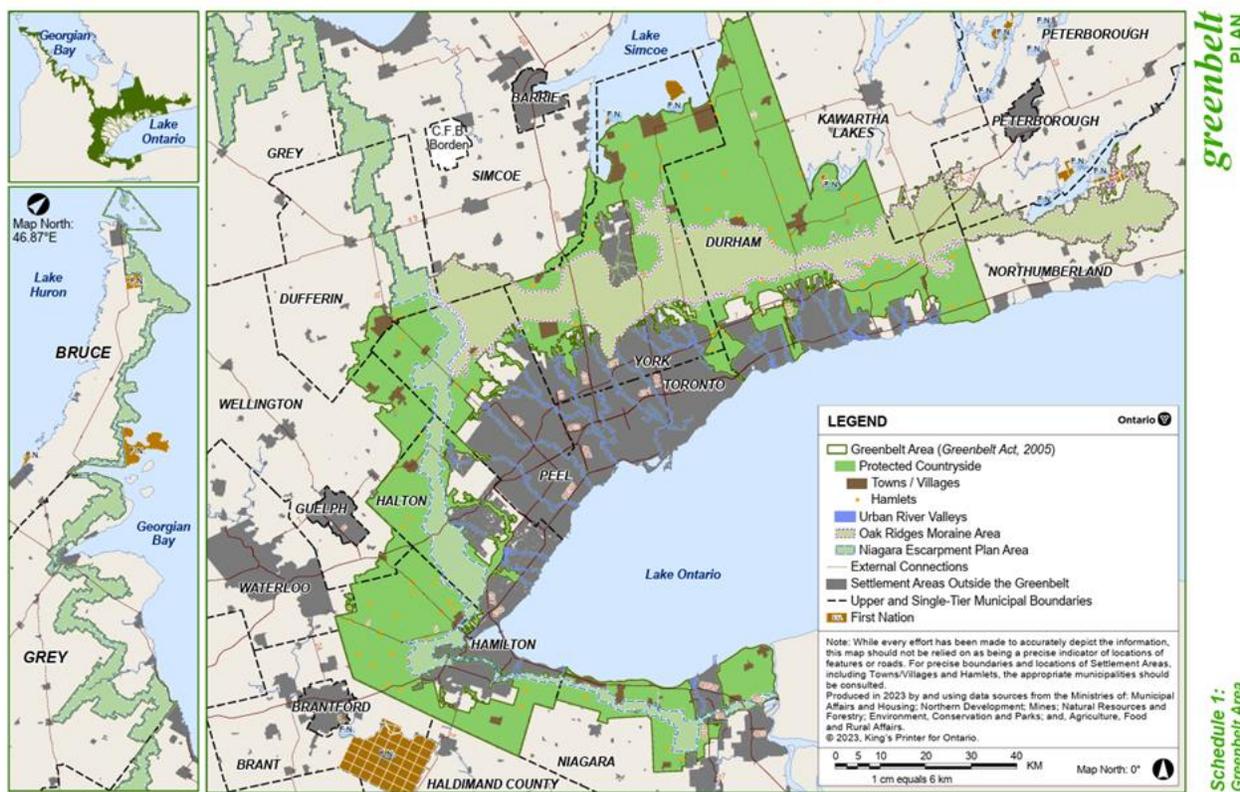


Figure 2. A map produced by the Government of Ontario (2023) depicting the Greenbelt as outlined in the Greenbelt Plan (2017).

Areas of significance that have been identified in the plan include:

1. Lands around the primary discharge zones along the toe of the Niagara Escarpment and base of the Oak Ridges Moraine;
2. The major river valleys that flow from the Oak Ridges Moraine and the Niagara Escarpment to Lake Ontario.

Key Natural Heritage Features and Key Hydrologic Features identified in The Plan (2017) include:

- Habitat of endangered species and threatened species;
- Fish habitat;
- Wetlands;
- Life science areas of natural and scientific interest (ANSIs);

- Significant valleylands;
- Significant woodlands;
- Significant wildlife habitat (including habitat of special concern species);
- Sand barrens, savannahs and tallgrass prairies; and
- Alvars
- Permanent and intermittent streams;
- Lakes (and their littoral zones);
- Seepage areas and springs

The Township of Cavan-Monaghan's Official Plan

The Township of Cavan-Monaghan's Official Plan (2021) aligns with the policies of the Provincial Policy Statement (2024), the Oak Ridges Moraine Conservation Plan (2017), and the Greenbelt Plan (2017). The plan prioritizes natural heritage features, hydrological features and ecological integrity. Below are policies within The Plan (2021) that can aid in identifying and valuing ecosystem services within the Baxter Creek subwatershed that align with Township's goals.

2.2.1 Natural Heritage, taken from the Township of Cavan-Monaghan's Official Plan (2021)

- a) Protecting the Oak Ridges Moraine for its unique landform characteristics, its significant function of groundwater recharge and discharge, its significant natural heritage features and their ecological functions;
- b) Identifying a continuous natural heritage system throughout the Township. This system will provide for the preservation of important ecological functions and features;
- c) Protecting groundwater resources as they are a vital component of the ecosystem and a source of drinking water.

6.1 Objectives, taken from the Township of Cavan-Monaghan's Official Plan (2021)

- b) Maintain, improve and, where possible, restore the health, diversity, size and connectivity of natural heritage features, hydrologically sensitive features and related ecological functions;
- c) Maintain natural stream form and flow characteristics and the integrity and quality of watercourses;
- e) Ensure that the Natural Heritage System is maintained as a series of interconnected natural features for the benefit of present and future generations
- i) Eliminate the potential for the loss or fragmentation of significant wetlands and the habitats and ecological functions they provide.

Conservation Authorities

It is common for Conservation Authorities to undertake studies to place a monetary value on their ecological assets. These value assessment studies are typically carried out to be used as a tool in gaining and retaining funding for areas under their authority. Associating a monetary value with the ecosystem services provided in an area provides quantifiable data which can be utilized to evaluate the return on investment when applying for funding and justify requested funding amounts.

This section of the report investigates the valuation of ecosystem services by Conservation Authorities in Ontario and covers what services are considered to have monetary values and what methods are used to determine those values.

The Toronto and Region Conservation Authority (TRCA) report published in 2018 (Green Analytics) assessed ecosystem services within the Authority's territory and assigned monetary estimates for the following services:

- Recreation
- Physical health
- Mental health
- Gas regulation (e.g. air quality)
- Carbon sequestration
- Food provision
- Aesthetic appreciation
- Habitat and refugia

Additional services which were considered to have monetary value but were not provided estimates in the report included:

- Disturbance regulation (e.g. flood mitigation)

- Temperature regulation
- Noise regulation
- Active transport
- Education and research benefits

The report provides annual total monetary value estimates for each category, which can be recalculated as a value per unit of service (user, metric tonne, or hectare) per year. The monetary values derived from the TRCA report are displayed in *Table 14*.

Table 14. Estimation of annual monetary values for ecosystem services based on TRCA evaluations.

Ecosystem Service	Indicator	Annual \$ Value	Per Unit
Recreation	Cycling/Biking	279	user
	Walking/Hiking	512	user
Physical Health	Meeting physical health guidelines by accessing greenspace	288	user
Mental Health	Reduction in number of people experiencing depression	945	user
Gas Regulation (air quality)	Air pollution removed	11576	metric tonnes
Carbon Sequestration	CO ₂ e sequestered	138	metric tonnes
Food Provision, Urban Agriculture	Fruit and vegetable production occurring in watershed	1153	metric tonnes
Aesthetic Appreciation	Area of natural cover	445	hectares
Habitat and Refugia	Area of natural cover	412	hectares

Calculation of monetary value estimates requires the assessment of units attributed to each category, which includes the quantification of annual users, area of ecological land use classifications, and the calculation of carbon sequestration provided.

Conservation Authorities have been able to quantify the value of physical and mental health for users, as research indicates that access to greenspaces reduces health system costs, as well as reducing productivity losses due to illness and poor mental health (Conservation Ontario, 2022). This quantification is not limited to Conservation Authority applications and can be utilized in smaller-scale applications managed by community organizations.

When calculating carbon sequestration, two methods can be used: net primary production (NPP) or net ecosystem production (NEP). Ontario Conservation Authorities, including Credit Valley Conservation, Lake Simcoe Region Conservation Authority and Toronto and Region Conservation Authority, utilize the NEP method as it accounts for the net carbon exchange between terrestrial ecosystems and the atmosphere, where NPP is limited to measuring the carbon uptake by vegetation alone (Moretto, Timmins, & Tonto, 2022). Once land cover has been inventoried, carbon sequestration can be calculated using many applications designed to measure sequestration based on land cover. Application suggestions are provided in the *Recommendations* section of this report.

A report published by Grey Sauble Conservation (Lanthier, 2018) uses additional metrics to provide monetary evaluation, including flood attenuation, educational opportunity, drought moderation, nutrient sequestration and freshwater supply and asserts that ecosystem services should be considered to have a value similar to other capital investments. This report does not provide values for individual categories, instead providing a dollar value per year per hectare of

land cover type. The report takes information from three studies which took place in Southern Ontario between 2008 and 2012, each of which utilized varying categories of land classification to determine ecosystem service values. The report's objective was to compare the valuation methods used in each study to determine which method was most relevant to areas contained within the Grey Sauble Conservation's territory and, therefore, the most accurate monetary evaluation of its ecosystem services. It can be discerned from the Grey Sauble report that when using land classification-based studies as a framework for ecosystem service valuation, it is important to select studies of areas which display the most similarity in land cover and use. *Table 15* provides an aggregate summary of relevant findings included in the Grey Sauble Conservation report, with mean values used for forest and wetland cover, which were included in both of the studies used for the creation of this table.

Table 15. Annual monetary values per area of land cover type derived from Grey Sauble Conservation report.

Land Cover Type	Value Per Hectare (\$/ha/Year)
Forest Mean	5,033
Wetland Mean	16,111
Pasture	1,785
Sparse Forest	2,617
Open Water	13,079
Grasslands	1,618
Cropland	477
Orchards	494
Idle Land	1,667
Rivers	335

A paper published by Conservation Ontario (Conservation Ontario, 2022) further iterates that ecosystem services provide economic benefits in Ontario by decreasing the negative impacts of natural hazards, including floods and erosion, which has the effect of preventing business disruption and reducing damage costs related to climate change and natural disasters. The paper continues to say that there is an economic value provided in the biodiversity, habitat (including pollinators) and water availability in natural ecosystems, which contribute to food security and industry. At this time, a valuation for these services does not appear. However, it should be noted that Conservation Authorities assert that there is a measurable value to these ecosystem services despite the exclusion of figures in reporting. Credit Valley Conservation (n.d.) states that while most ecosystem goods and services do not have clear market values, estimating their monetary value can aid in better management of natural assets, and they are currently working with partners to build evidence supporting valuation. Furthering efforts to build evidence supporting valuation, Credit Valley Conservation has developed a tool that aids in understanding the effects of flooding and erosion to place a dollar value on potential direct and indirect damages under different scenarios to perform financial assessments.

Conservation Authorities have a long history of ecosystem service valuation. Generated reports are often specific to certain watersheds and not up to date with current economic conditions however, these reports provide source material for building a valuation estimate which can be updated, customized and applied to the Baxter Creek subwatershed.

Baxter Creek Ecological Land Classification and Ecosites

The objective of this section is to explore existing data sources and methodologies for identifying and characterizing ecosites in the Baxter Creek subwatershed. The focus is on evaluating the availability and applicability of Ecological Land Classification (ELC) data using tools such as the Southern Ontario Land Resource Information System (SOLRIS) Version 3.0 and the Ontario Watershed Information Tool (OWIT). This exploratory phase aims to define a clear path for integrating ELCs into the Baxter Creek Watershed Alliance's (BCWA) decision-making and management strategies, while also supporting the ecosystem service valuation (ESV) approach outlined earlier in this report.

Ontario's ELC Framework:

Ontario's ELC system provides a standardized method for describing ecological communities. It categorizes landscapes based on multiple layers of biophysical data, including vegetation structure and composition, soil type and moisture regime, geology, and hydrology. The ELC system uses a hierarchical classification structure, from broad ecozones to detailed ecosite types, and is commonly applied in land-use planning, habitat evaluation, and conservation.

The goal of ELC mapping is to accurately represent ecosystems on the landscape to support informed decision-making such as assigning ESVs to land units based on their ecological function, as discussed in earlier sections of this report.

Table 16. Ecological classification units used in Ontario. Highlighted row shows ecosite level, which is the focus of this report (MNR, 1998).

Classification Unit ¹	Appropriate Scale ²	Recommended Tools ³	Example of Management Applications
Ecozone	1:3,000,000 10,000-1,000,000 km ²	Wiken (1986)	Ecological context for Ontario; planning; policy
Ecoprovince	1:1,000,000 10,000-100,000 km ²	Wiken (1986)	Ecological context for Ontario; planning; policy
Ecoregion	1:500,000 1000-10,000 km ²	Hills's Site Regions of Ontario (Hills 1961, Burger 1993)	Strategic planning at regional or sub-regional levels; policy
Ecodistrict	1:250,000-1:500,000 100-1000 km ²	Hills's Site Districts of Ontario (Hills 1961)	Strategic planning at sub-regional level, watershed plans; policy
Ecosection	1:100,000-1:250,000 1000-10,000 ha	Ontario Land Inventory (OMNR 1977), Physiography of Southern Ontario (Chapman and Putnam 1984)	Major landform contributions for forest prime land, broad habitat trends, watershed and subwatershed plans
Ecosite	1:10,000-1:20,000 10-100 ha	Ecological Land Classification for Southern Ontario: First Approximation and Its Application	Ecosystem mapping ; conservation; inventory ; regional planning; evaluation ; silvicultural ground rules; wildlife habitat; subwatershed plans
Ecelement	1:2,000-1:10,000 100-100,000 m ²	Vegetation Type in the Ecological Land Classification for Southern Ontario: First Approximation and Its Application	Site and stand level research; inventory; development proposal; environmental impact assessment; evaluation; conservation

Organization of the ELC Framework

The ELC is made up of six nested levels. From the largest to the smallest scale, they are:

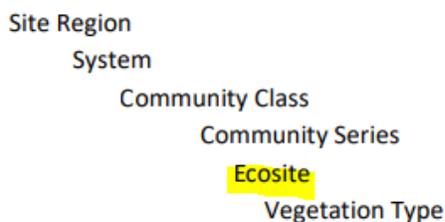


Figure 3. Schematic of ELC framework hierarchy (MNR, 1998). Classification unit of interest is highlighted.

Ecosites are defined as relatively uniform landscape units that reflect repeating vegetation patterns and environmental conditions (Canada Committee on Ecological Land Classification, 1998). Key ELC characteristics include vegetation cover type and structure; soil texture, drainage, and moisture regime; bedrock geology and slope; and hydrological conditions. According to the ELC Manual for Southern Ontario, classification is conducted using nested keys that distinguish between observable biophysical features (MNR, 1998).

Geology	Soils	Vegetation
bedrock type	depth	structure
	texture	species composition
	moisture regime	physiology
	nutrient regime	
	drainage	

Figure 4. Biophysical characteristics used for ELC (MNR, 1998).

These criteria are used in tandem to define and differentiate ecosites across a landscape. Tools like SOLRIS and OWIT can help infer some of these variables remotely, though field verification is often required for full accuracy.

According to the ELC Manual for Southern Ontario, classification is conducted using nested keys that distinguish between terrestrial, wetland, and aquatic ecosites, based on observable biophysical features (MNR, 1998).

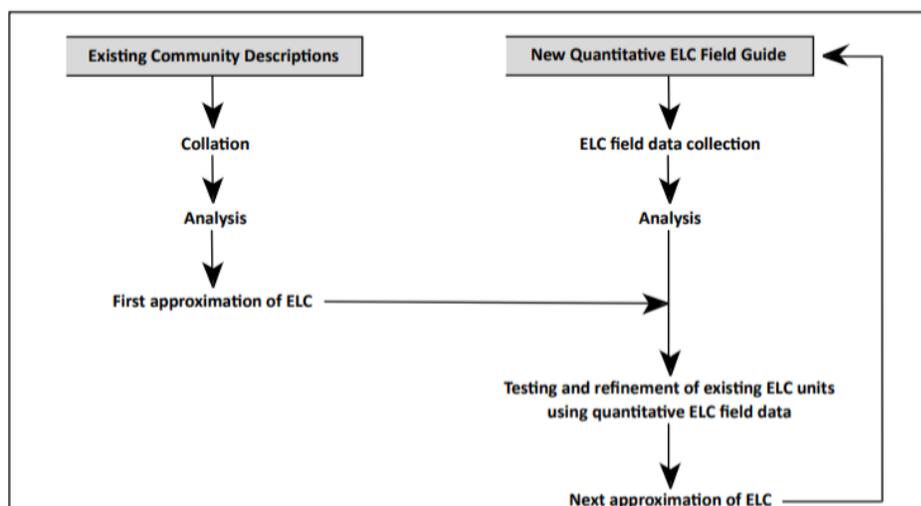


Figure 5. Schematic of the iterative approach used to develop ELC in Southern Ontario (MNR, 1998).

The ELC system evolves through a feedback loop of analysis, data collection, and testing. This process helps transform initial approximations of ecological units into standardized and field-tested classifications, which can then be applied in management and planning. This is

particularly important when considering whether SOLRIS or OWIT-based data is robust enough for Baxter Creek or if further refinement is needed through fieldwork.

System	Site	Substrate	Topographic Features	History	Cover	Plant Form	Community
Terrestrial	Open Water	Organic	Lacustrine	Natural	Open	Plankton	Lake
Wetland	Shallow Water	Mineral Soil	Riverine	Cultural	Shrub	Submerged	Pond
Aquatic	Surficial Deposits	Parent Mineral Material	Bottomland		Treed	Floating-leaved	River
	Bedrock	Carbonate Bedrock	Terrace			Graminoid	Stream
		Basic Bedrock	Valley Slope			Forb	Marsh
		Acidic Bedrock	Tableland			Lichen	Swamp
			Rolling Upland			Bryophyte	Fen
			Cliff			Deciduous	Bog
			Talus			Coniferous	Barren
			Crevice / Cave			Mixed	Meadow
			Alvar				Prairie
			Rockland				Thicket
			Beach / Bar				Savannah
			Sand Dune				Woodland
			Bluff				Forest
							Plantation

Figure 6. Schematic illustrating the eight descriptive fields used in Ontario's ELC Polygon Description Framework (MNR, 1998).

To accurately classify ecosites, the ELC framework uses eight key descriptive fields (Figure 6). These include system type, soil and bedrock substrate, topographic features, vegetation cover, and plant community structure. While tools like SOLRIS provide useful information on land cover and hydrology, many of these fields such as soil mineralogy, plant form, or historical disturbance, require field observation. This highlights the limitations of relying on remote sensing alone and the need for eventual field data collection in Baxter Creek.

Available Data Sources:

- *Southern Ontario Land Resource Information System (SOLRIS 3.0).*

SOLRIS is a remotely sensed land cover classification system produced by the Ontario Ministry of Natural Resources and Forestry (MNRF). SOLRIS Version 3.0 provides land cover

data across Southern Ontario, including the Baxter Creek area. It is coarse in scale but covers a wide area consistently and is useful for general ecosystem characterization. SOLRIS advantages include province-wide coverage, consistent raster and vector data format for use in GIS and readily available to the public via Ontario GeoHub.

However, some limitations exist such as coarse resolution which may not accurately reflect local variation in ecosites, complex legend and interpretation challenges, and the fact that SOLRIS cannot fully replace field-verified data.

A review of SOLRIS data for Baxter Creek (*Figure 7*) reveals a mix of wooded areas, open water, wetlands, agriculture, and settlement zones, consistent with typical Southern Ontario land mosaics. However, the ELC classification codes are not explicitly available within the SOLRIS dataset, making interpretation dependent on cross-referencing with SOLRIS documentation (MNRF, 2020).

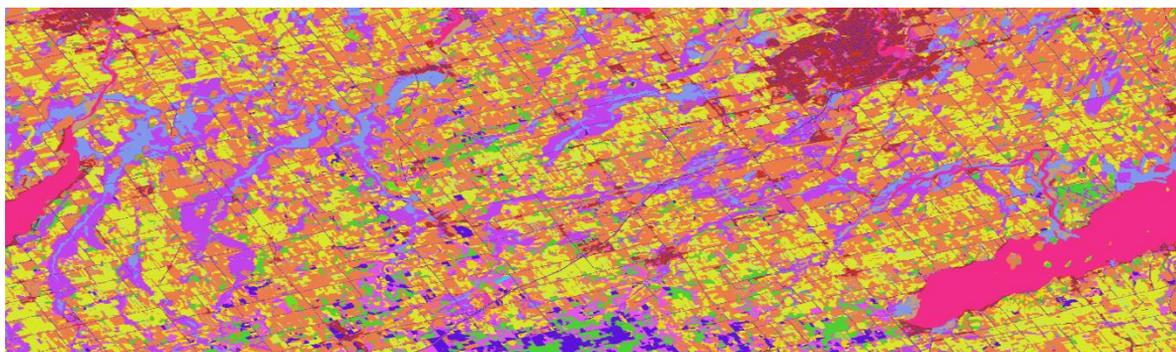


Figure 7. Land cover classification and watershed boundary of the Baxter Creek area according to SOLRIS 3.0, as visualized using QGIS.

- *Ontario Watershed Information Tool (OWIT).*

OWIT is a web-based GIS platform that visualizes wetlands and land use information across Ontario. It allows users to view wetland boundaries, classifications, and land cover data within a spatial context. Provides visual identification of vegetated and hydrologically

influenced areas, includes provincially significant wetlands and can support verification of wetland ecosites. However, OWIT does not directly provide ELC unit classification, so its role is more contextual and supplementary.

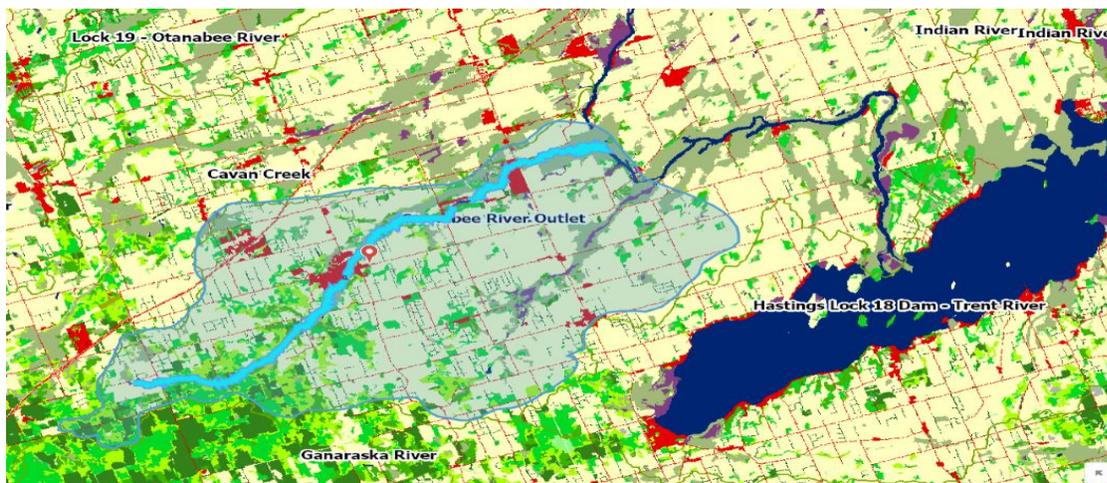


Figure 8. Land cover and watershed boundary visualization of the Baxter Creek area generated using the Ontario Watershed Information Tool (OWIT).

Figure 8, generated using the Ontario Watershed Information Tool (OWIT), illustrates the Baxter Creek sub watershed boundary and surrounding land cover. OWIT enables users to quickly assess vegetation patterns, hydrology, and development pressures across a landscape, offering a useful visual supplement to more detailed datasets like SOLRIS. In this case, OWIT helped identify potential ecological zones of interest such as forest patches and riparian corridors, guiding the preliminary delineation of ecosites within the watershed.

Table 16. Details of data availability based on different sources and categories.

Category	Source Reviewed	Data Availability	Notes
Land Cover	SOLRIS 3.0	Available	Publicly downloadable from Ontario GeoHub
ELC Maps	ORCA / MNRF	Not available	No known field-based ELC mapping for Baxter Creek

Watershed Details	OWIT	Available	Useful for visual support and verifying wetland presence
Ecosite Details	Fieldwork	Not yet available	Field verification may be needed in future

Based on the sources studied and the availability of data, we can interpret that while remote sensing and visual interpretation tools like SOLRIS and OWIT provide a helpful starting point, they cannot replace the detail and accuracy of field-based ELC mapping. Key variables such as soil moisture regime, vegetation community structure, and substrate type are not fully captured in these datasets, meaning any ELC mapping at this stage remains preliminary.

To move toward a more robust classification we recommend:

- SOLRIS can be used to outline likely land cover zones (e.g., forests, wetlands, agriculture).
- OWIT can supplement this by identifying areas of ecological interest such as wetlands, riparian buffers, or woodland patches.
- Fieldwork, though not part of this phase, will be needed in the future to develop site-scale ELC polygons and validate initial mapping results.

Methodological Approach:

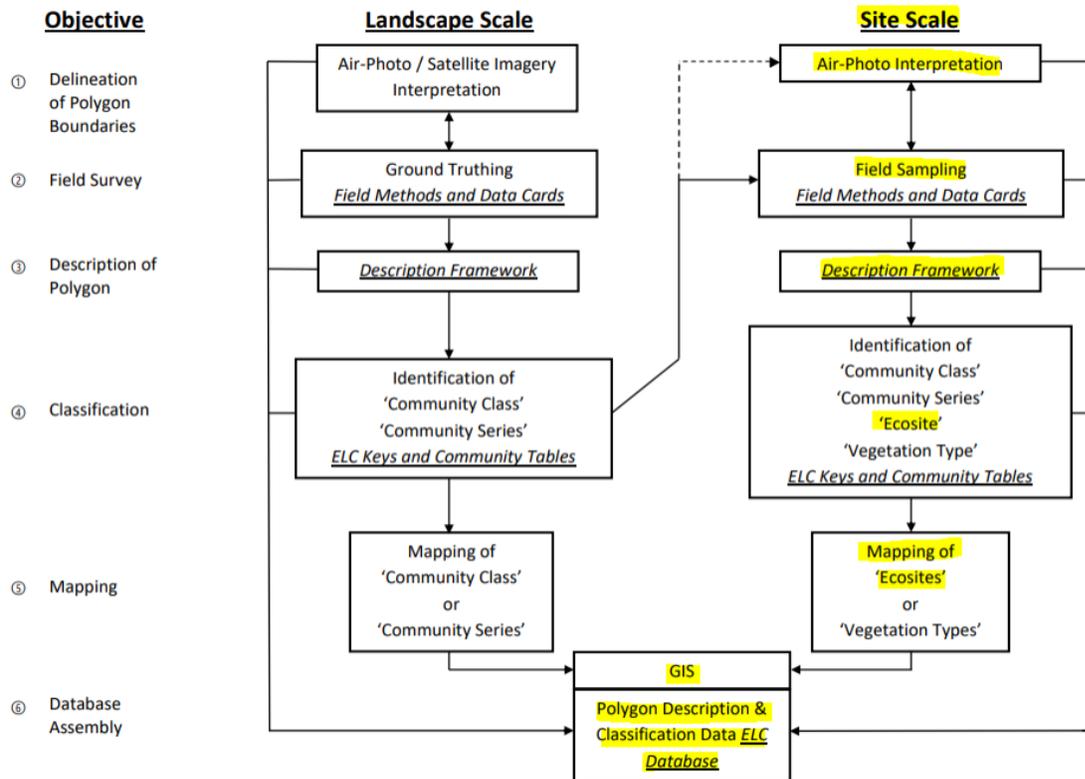


Figure 9. Schematic showing how landscape and site-scale tools feed into the ELC classification process. Highlighted elements illustrate key stages relevant to this project, including air-photo interpretation, ecosite mapping, and database development (MNR, 1998).

The highlighted components from Figure 9, such as air-photo interpretation, ecosites, and mapping of ecosite, demonstrate how SOLRIS can support early landscape-scale analysis, while field-based work and community input are needed for detailed classification. Though high-resolution field data is ideal for ecosite classification, this exploratory phase makes use of available landscape-level tools to establish a foundation.

Earlier sections of this report outlined the importance of assigning ESVs to land classes based on ecological function. By using SOLRIS and OWIT, a preliminary inventory of ecosites can be developed, which in turn can be linked to ESV categories.

For example, forest cover identified through SOLRIS may correspond to a deciduous forest ecosites in the ELC framework, which could be assigned high ESVs for biodiversity and climate regulation. Similarly, OWIT-identified wetlands may align with deciduous swamp ecosites, known for their water retention and nutrient cycling functions.

To make these connections reliable, field-based ELC verification may be needed, supported by spatial tools. This can help prioritize areas for valuation and conservation. Therefore, based on the workflow suggested by the ELC framework, we recommend the following approach:

GIS-Based Interpretation Using SOLRIS:

- o Load SOLRIS raster data into QGIS
- o Overlay with known sub watershed boundary (Baxter Creek)
- o Use classification symbology to extract major land cover types
- o Attempt to crosswalk land cover types with general ELC ecosites using literature and the ELC manual

OWIT Visual Inspection

- o Identify wetland presence and extent
- o Use "Identify" tool to examine land use overlays in the sub watershed
- o Compare visual patterns to SOLRIS data for validation

Preliminary Findings:

- SOLRIS 3.0 includes data for the Baxter Creek watershed but lacks detailed ELC classification.
- Most of the watershed includes mixed land cover, notably woodlands, cropland, and wetlands.
- OWIT confirms the presence of wetlands and riparian zones, likely associated with distinct ecosites.
- There is no existing fine-scale ELC mapping for the area; data is limited to coarse provincial datasets.

This exploratory study of ESVs confirms that coarse-scale remotely sensed data such as SOLRIS 3.0 provides a useful starting point for ecosite identification and land classification in the Baxter Creek watershed. However, the lack of field-verified ELC mapping by conservation authorities and the limitations of OWIT as a classification tool suggest the need for more refined data collection in the future. This foundational work lays the groundwork for future efforts to integrate ELCs into watershed planning, restoration, and ecosystem service valuation at the community scale.

Recommendations

Based on our research findings, we recommend the following for BCWA in regard to pursuing ESV in their subwatershed:

1. Our findings suggest that ESV can be a helpful tool when advocating for sustainable development in the context of urbanization, development, and other land use changes. Therefore, we affirm that ESV could be one useful tool for BCWA to use in their political advocacy and public communications.
2. If resources allow it, consider conducting a full ecosystem services valuation by consulting with a professional ecological economist.
3. If resources do not allow for a full valuation, consider using the value transfer approach to ESV, by using pre-existing ESV studies from similar watersheds and contexts as the basis for valuation.
4. If using the value transfer approach, remember to account for inflation since the time of the studies you are using. Other sources of value change should be considered, as well, based on differences in context.
5. Contact Credit Valley Conservation regarding their flooding and erosion mitigation valuation tool.
6. Consider using the Blue Carbon Calculator and the Government of Canada's Generic Budget Carbon Model (CBM-CFS33) to estimate carbon sequestration within the Baxter Creek subwatershed.
7. Begin building a custom ELC layer for the Baxter Creek area using SOLRIS plus future field data.

8. Use SOLRIS 3.0 for preliminary mapping but clearly state its limitations in resolution and ecosystem accuracy.
9. Consider initiating a partnership with ORCA or academic institutions such as Trent University for future field-based ELC surveys.
10. Use OWIT to complement and verify spatial relationships between land cover and ecological features.
11. Advocate for the development of a refined ELC framework specific to the subwatershed using both remote sensing and in-field approaches.

We'd like to thank the Baxter Creek subwatershed Alliance for this opportunity to help in this important work. We hope that you find these findings and recommendations helpful in the continuation of your organization's work.

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Appendix I.

Additional PPS Policies

4.1.6. Development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements.

4.1.7. Development and site alteration shall not be permitted in habitat of endangered species and threatened species, except in accordance with provincial and federal requirements

4.1.8. Development and site alteration shall not be permitted on adjacent lands to the natural heritage features unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions.

4.2.1. Planning authorities shall protect, improve or restore the quality and quantity of water by:

a) using the watershed as the ecologically meaningful scale for integrated and long-term planning, which can be a foundation for considering cumulative impacts of development;

c) identifying water resource systems;

d) maintaining linkages and functions of water resource systems;

e) implementing necessary restrictions on development and site alteration to:

1. protect all municipal drinking water supplies and designated vulnerable areas; and

2. protect, improve or restore vulnerable surface and ground water, and their hydrologic functions;

4.2.5. All municipalities undertaking watershed planning are encouraged to collaborate with applicable conservation authorities.

The Oak Ridges Moraine Conservation Plan Permitted Uses of Areas

Natural Core Areas - Protecting these lands is vital to maintaining the integrity of the Moraine, as they contain the greatest concentrations of key natural heritage features. Aside from existing uses, the only uses that will be permitted in these areas are resource management, agriculture, low-intensity recreation, home businesses, transportation and utilities.

Natural Linkage Areas - These areas protect natural and open space linkages between the Natural Core Areas and along rivers and streams. The uses permitted in the Natural Core Areas are also permitted in Natural Linkage Areas. Additionally, some aggregate resource operations are permitted.

Countryside Areas—These areas are intended to provide an agricultural and rural transition and buffer between the Natural Core, Linkage Areas, and Settlement Areas. They protect prime agricultural areas and natural features.

Settlement Areas – These areas include existing communities; urban uses and development as set out in official municipal plans are permitted.

The Greenbelt Plan Additional Policies

Subwatersheds - Section 27

3) With respect to land in Settlement Areas, in considering applications for development or site alteration with respect to land in a subwatershed, the approval authority shall consider the importance of:

- a) ensuring that natural vegetation is maintained, and where possible improved or restored; and
- b) keeping to a minimum impervious surfaces and their impact on water quality and quantity.

Appendix II.

Carbon sequestration calculation tools

Minimum Data Requirements	Asset Types					
	Local-scale			Landscape-level		
	Individual trees	Street and park trees	Urban forest	Wetlands	Forest patches or stands	Land cover patches / landscapes
• Tree species • Diameter at breast height (DBH)	<ul style="list-style-type: none"> • i-Tree • MyTree • i-Tree Design 					
• Tree Inventory	<ul style="list-style-type: none"> • i-Tree Eco 					
• Plot based data	<ul style="list-style-type: none"> • i-Tree Eco 					
• Area of the restoration project	<ul style="list-style-type: none"> • Blue Carbon Calculator 					
• Forest type • Forest age or volume	<ul style="list-style-type: none"> • CBM-CFS3 • Volumetric Method 					
• Land use land cover	<ul style="list-style-type: none"> • InVEST Carbon Storage & Sequestration • InVEST Forest Carbon Edge Effect 					
• Ecological Land Classification (FLC) map	<ul style="list-style-type: none"> • Business Case for Natural Assets (BC4NA) 					
• No data	<ul style="list-style-type: none"> • ABC-Map • i-Tree Canopy 					

(Moretto, Timmins, & Tonto, 2022)

Tool/ Method	Outputs					
	Current Carbon Stored	Current Gross Sequestration	Current Net Sequestration	Projected Carbon Stored	Projected Gross Sequestration	Projected Net Sequestration
ABC-Map	X			X		
Blue Carbon Calculator			X			X
Business Case for Natural Assets (BC4NA)	X	X		X	X	
CBM CFS3	X	X	X	X	X	X
InVEST Carbon Storage & Sequestration	X	X				
InVEST Forest Carbon Edge Effect	X	X				
i-Tree Canopy	X	X				
i-Tree Eco	X	X	X	X	X	X
i-Tree Design	X	X		X	X	
i-Tree MyTree	X	X				
Volumetric Method	X	X		X	X	

(Moretto, Timmins, & Tonto, 2022)

Appendix III.

Watershed valuation reference

APPENDIX – I: DATA RESULTS FOR GSC LAND HOLDINGS					
MNR Study (Troy and Bagstad, 2009)					
Land Cover Type	Dollar Value per Hectare per Year	GSC Property Areas (ha)	Percent of Land Holding	Service Value per Year	Percent of Total Land Value
Agriculture	\$291	86.9	0.7%	\$25,288	0.0%
Grassland/Pasture/hayfield	\$353	117	1.0%	\$41,301	0.1%
Forest: non-urban	\$4,443	9424	80.3%	\$41,870,832	61.5%
Open Water: River	\$55,553	42.8	0.4%	\$2,377,668	3.5%
Open Water: Inland Lake	\$5,050	340.7	2.9%	\$1,720,535	2.5%
Open Water: Estuary / Tidal Bay	\$1,852	13.6	0.1%	\$25,187	0.0%
Wetlands: non-urban, non-coastal	\$15,171	1442.7	12.3%	\$21,887,202	32.1%
Wetlands: Great Lakes Coastal	\$14,761	1.2	0.0%	\$17,713	0.0%
Beach (general)	\$89,608	0	0.0%	\$0	0.0%
Beach near structure	\$130,068	1.1	0.0%	\$143,075	0.2%
Beach not near Structure	\$49,150	0.3	0.0%	\$14,745	0.0%
Undifferentiated Poor Agriculture	\$0	61.7	0.5%	\$0	0.0%
Other Unvalued Terrestrial	\$0	84.6	0.7%	\$0	0.0%
Total				\$68,123,546	
Muskoka Watershed Study (Austin et al, 2012)					
Land Cover Type	Value Per Hectare (\$/ha/Year)	Area (ha)	Percent of Land Holding	Total Value	Percent of Total Land Value
Forest	\$4,651.69	9424	80.3%	\$43,837,526.56	58.7%
Wetland	\$17,968.32	1442.7	12.3%	\$25,922,895.26	34.7%
Pasture	\$1,785.26	117	1.0%	\$208,875.42	0.3%
Sparse Forest	\$2,616.75	80.2	0.7%	\$209,863.35	0.3%
Open Water	\$13,079.22	340.7	2.9%	\$4,456,090.25	6.0%
Total				\$74,635,250.85	
Greenbelt Study (Wilson, 2008)					
Land Cover Type	Value Per Hectare (\$/ha/Year)	Area (ha)	Percent of Land Holding	Service Value per Year	Percent of Total Land Value
Forest	\$5,414	9424	80.3%	\$51,021,536.00	70.9%
Wetlands	\$14,253	1442.7	12.3%	\$20,562,803.10	28.6%
Grasslands	\$1,618	107.4	0.9%	\$173,773.20	0.2%
Cropland	\$477	86.9	0.7%	\$41,451.30	0.1%
Orchards	\$494	0	0.0%	\$0.00	0.0%
Idle Land	\$1,667	89.6	0.8%	\$149,363.20	0.2%
Rivers	\$335	42.8	0.4%	\$14,338.00	0.0%
Other	\$0	66.1	0.6%	\$0.00	0.0%
Total				\$71,963,264.80	

(Lanthier, 2018)