Major Research Paper

Impacts of changes to the Ontario Wetland Evaluation System on Wetlands in Southern Ontario

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Abstract

Wetlands in Southern Ontario play important roles in supporting biodiversity and providing ecosystem services. Wetlands ecosystem services include water quality regulation through phosphorus retention, reducing flood risks, storing carbon, regulating climate, and supporting high levels of biodiversity. In November 2022, The *More Homes Built Faster Act*, 2022, introduced changes to how wetlands are evaluated for protection in Ontario under the Ontario Wetland Evaluation System. In the new evaluation system, species at risk are considered only "provincially tracked species", which are worth significantly fewer points under the new scoring system. Additionally, wetlands will no longer be evaluated as complexes, made up of smaller individual wetland units. Rather the individual wetland units can be removed from the complex and evaluated individually making it increasingly difficult for small wetlands to reach the minimum scoring criteria to be designated as a provincially significant wetland. This study aims to model the impact of this policy change on provincially protected wetland area in Southern Ontario, as well as the impacts on ecosystem benefits and services provided by wetlands. Kemptville, Essex, Toronto, and Grimsby ecodistricts were selected as the study sites as they are historically the most vulnerable to wetland loss in the past 20 years. It was found that over 22,500 Hectares of wetland across Southern Ontario will be vulnerable to losing provincial protection due to the no-complexing change to the evaluation system. Additionally, it was found that those 22,500 hectares of small wetlands provide over 15 billion dollars annually in ecosystem services. It is recommended that provincial policymakers consider the environmental and economic impact of stripping wetlands of protection and prioritize these ecosystems for future conservation efforts.

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1.1 Wetlands in Southern Ontario

Southern Ontario was once covered with forests, interspersed with wetlands, lakes, and rivers. From the establishment of European Settlements to today, almost three-quarters of these wetlands have been lost (Penfound & Vaz, 2022a). Yet, the provincial government is enabling the continued destruction of the remaining wetlands in favor of agriculture, urban development, and aggregate extraction (Environmental Commissioner of Ontario, 2018a).

The term “wetland” is used as a generic term for “land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment (Canadian Council of Academics, 2022). Wetlands are generally organized within five categories: bogs, fens, marshes, swamps and shallow water, based on their dominating characteristics of vegetation, soil and terrain (Medland et al., 2020)

Drivers of wetland loss in Southern Ontario include urban and suburban development and agricultural expansion (Penfound & Vaz, 2022b). Anthropogenic influences cause the greatest negative impacts to wetlands, and especially near highly developed areas, have significant impacts on the quality and quantity of water available to sustain wetland systems (Croft-White et al., 2017). The main causes of wetland degradation are hydrological alterations, salinization, eutrophication, sedimentation, filling, and exotic species invasions (Zedler & Kercher, 2005a).

In Southern Ontario, wetland drainage to facilitate agricultural expansion is considered the most prominent factor, contributing to an estimated 81-85% of wetland loss (Walters & Shrubsole, 2003). While the approval of an individual drainage work may appear insignificant, the cumulative impact of these decisions results in significant losses of function, value, and wetland area (Walters & Shrubsole, 2005). The process of draining wetlands interrupts anoxic (oxygen-poor) conditions prevalent during waterlogging, exposing the soils to air. This accelerates the decomposition of organic material into carbon dioxide but also reduces the production of methane.

Climate change has also been identified as an important threat to wetlands, where it is expected to affect the hydrology of individual wetland ecosystems mostly through changes in precipitation and temperature regimes with great global variability (Erwin, 2009). Wetland degradation driven by these anthropogenic factors can have significant impacts on ecosystem services, which are the benefits that ecosystems provide to humans and the biodiversity they support.

1.2 Wetland Ecosystem Services

Wetlands perform several ecosystem services, making them important at local and global levels. At a local level, wetlands purify contaminated or polluted water, provide flood control, stabilize shorelines, provide storm protection, replenish groundwater, and contribute to biodiversity by providing a home for many species of flora and fauna (Penfound & Vaz, 2022b). At the global level, wetlands help to regulate the climate, maintain the water cycle, and facilitate carbon sequestration (T. Xu et al., 2019). These services have real and quantifiable value, although they are largely unrecognized externalities in our economy (Narayan et al., 2017). Economic valuation of ecosystem services can be instrumental in decision making that incorporates the contributions of nature to human well-being (Daily et al., 2009).

1.2.1 Valuation of ecosystem services

Using economic values for ecosystem services recognizes the vital importance of natural ecosystems, which through much of history have provided services for “free”, meaning that society has been benefiting from ecosystem services worth many trillions of dollars without ever having to pay for them (DeLoyde & Mabee, 2023). Economic development that treats ecosystem services as “free” can result in market failures or “externalities”. This means that the benefits provided by wetlands are not fully reflected in market transactions, which can lead to poor policy decisions, resulting in ecosystem degradation and destruction (DeLoyde & Mabee, 2023).

The value of ecosystem services is estimated by attempting to quantify the benefits provided by the ecosystem. The economic valuation of wetlands services can be divided into two categories: Use value and Non-use value (Figure 1.) Use value refers to the direct benefits that humans derive from wetlands through their utilization. These benefits can be both tangible and measurable. Some examples of use values associated with wetlands include flood control, water filtration and carbon storage. Non-use value, on the other hand, refers to the value that individuals place on wetlands even if they never directly utilize or interact with them. This value is more abstract and may be based on ethical, aesthetic, cultural, or existential considerations. Non-use value can be divided further into two categories: Existence value and Bequest value. Existence value reflects the value that people place on knowing that wetlands exist, regardless of whether they benefit from them. Bequest value is related to the desire to preserve wetlands for future generations. It reflects the value people place on ensuring that wetlands are maintained and protected as part of their legacy to future generations. Non-use values can be more challenging to quantify, as they are not linked to market transactions, however non-market-based approaches such as willingness to pay valuations can be used to estimate their value.

Because wetland functions differ with type, size, and position in the watershed (Zedler & Kercher, 2005a), it's important to gather information about the wetland's physical and biological characteristics. Ecosystem services can then be quantified using scientific analysis or modelling. For regulating services such as water filtration, phosphorus or sedimentation retention rates would be quantified. To translate these ecosystem services into a monetary valuation, 3 valuation approaches can be undertaken.

Market-based valuations estimate ecosystem service values based on market prices through value transfer. For example, the market value of a forest's ability to produce raw materials can be estimated from the monetary value of timber being provided by the forest. Cost-based valuations estimate the value of an ecosystem service based on the cost savings that are provided. For example, the value of water filtration services provided by a wetland can be estimated by comparing the difference in water treatment costs before and after wetland degradation. Willingness to pay valuation is a method used to assess the economic value of an ecosystem based on how much individuals are willing to pay for it, which can be estimated through public surveys or choice experiments. These various valuation approaches can be used to value different types of ecosystem services, where one method may be more applicable than another. It is also important to note that there is significant uncertainty associated with ecosystem service valuation, possibly due to data limitation, the complexity and dynamic nature of ecosystems, and inherent bias in human behavior.

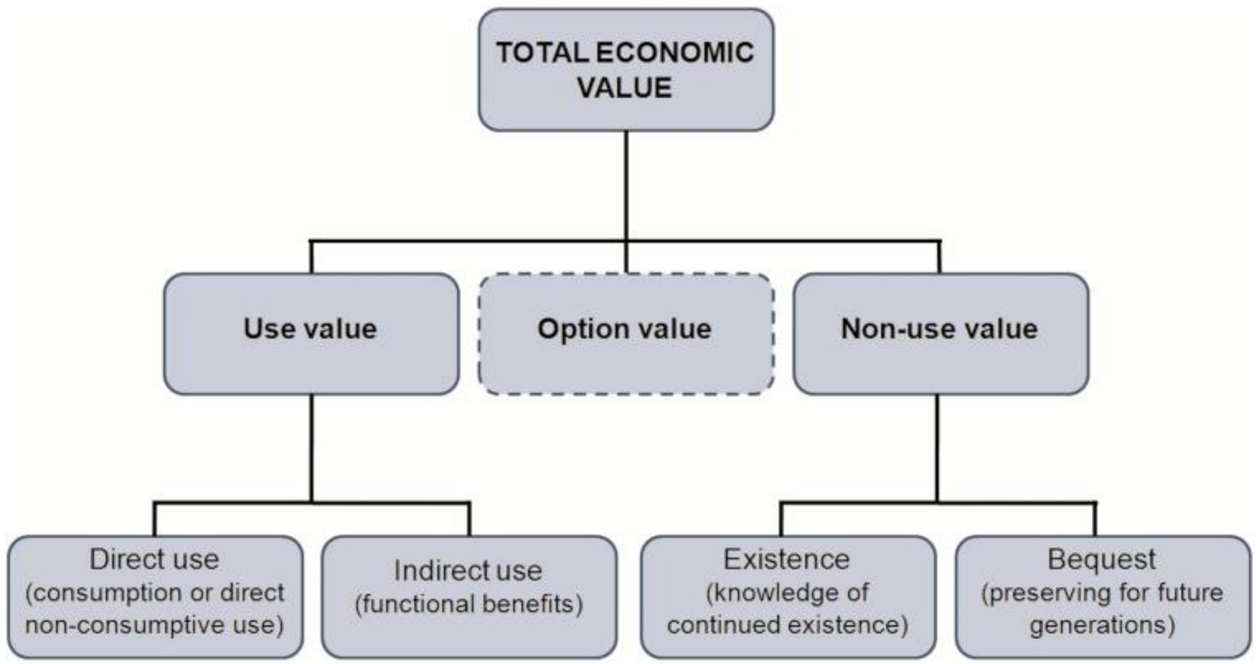

Figure 1. The Total Economic Value (TEV) framework for valuation of ecosystem services (adapted from Ledoux & Turner 2002, Chee et al. 2004, Saunders et al. 2010).

1.2.2 Water Filtration

Globally, eutrophication is a significant threat to freshwater quality (Page et al., 2023). Lakes and rivers across southern Ontario are suffering from nutrient loading, resulting in the loss of recreational opportunities and water quality. Phosphorus loading from agriculture and urban runoff has been identified as a major cause of this environmental problem and a major public health issue (Pattison-Williams et al., 2017). Wetlands have been widely acknowledged for their capacity to intercept and retain non-point source nutrients, acting as buffers to reduce the nutrient loading to downstream lakes (Page et al., 2023; Yang et al., 2016)

Freshwater wetlands trap sediments, sequester nutrients, and filter water through physical (sedimentation), chemical (absorption, precipitation, chelation) and biological (plant uptake) processes (Aziz & Van Cappellen, 2021). Nutrients such as phosphorus and nitrogen are readily removed by the organic material within wetlands, avoiding costly chemical or mechanical filtration techniques. Wetlands are considered an environmentally positive and cost-effective method for treating wastewater, requiring minimal operational and maintenance costs to achieve equivalent secondary treatment effluent results (Pattison-Williams et al., 2017).

1.2.3 Carbon Storage and Climate Regulation

Natural wetlands can act as a long-term terrestrial carbon sink by storing peat (plant organic litter undergoing very slow decomposition) under waterlogged conditions (Byun et al., 2018). Freshwater wetlands contain significant carbon stocks due to their extensive area globally and their potential to accumulate organic carbon at high rates in surface and deep soils (Loder et al., 2023)

Avoided conversion of existing wetlands to other uses or restoring previously existing wetlands that have been damaged or reduced has been identified as an important opportunity among wetland-related natural climate solutions for providing net carbon uptake and mitigation against greenhouse gas emissions in Canada by 2030 (Canadian Council of Academics, 2022; Drever et al., 2021).

Although wetlands are considered to be important carbon sinks, an accurate estimation of greenhouse gas fluxes is important for calculating the sequestration potential of wetlands. In addition to carbon dioxide fluxes, it is also important to consider methane and nitrate emissions from wetlands in order to understand the net movement of greenhouse gases between wetlands and the atmosphere. Peatlands have a relatively well-known, long-term average rate of carbon accumulation of about 0.23t of carbon per hectare per year, but regional (climate) and local (hydrological position in landscape) factors can influence the rate of carbon accumulation in individual peatlands (Canadian Council of Academics, 2022). (Frolking et al., 2006) modelled methane and carbon dioxide pools in the atmosphere to quantify the dynamics of both greenhouse gases over years to millennia, to determine the net radiative forcing impact of a peatland that continuously emits methane and sequesters carbon dioxide. They found that net warming peaks at about 50 years and continues to diminish for the next several hundred to several thousand years, and thereafter will be an ever-increasing net cooling impact. This research indicates that although wetlands may not act as a viable short-term nature-based climate solution, they may have important long-term impacts on global climate. Additionally, the conservation of wetlands may act as an important long-term method of carbon emissions reduction as the conversion of wetlands to other land uses, such as agriculture or urban development, often leads to the release of carbon stored in wetland ecosystems through the removal of vegetation and disturbance of soils.

1.2.4 Flood Control

Wetlands regulate the flow of water providing protection against flooding and erosion. Wetlands and floodplains act as green infrastructure to mitigate flooding by storing and slowing floodwater so that it arrives downstream gradually rather than in a single large pulse (Narayan et al., 2017). Changes in stream flow due to forest and wetland loss results in lower water levels during dry seasons, higher than normal water levels in wet seasons or storms, greater amounts of sediment entering rivers, and increased water temperatures.

Many climate scenarios indicate increases in annual total precipitation as well as increases in heavy precipitation events, suggesting that the importance of wetlands for human well-being will also increase (Deng et al., 2016, 2018; Wang et al., 2016). A study cited in the

2019 report of Ontario's special advisor on flooding found that maintaining wetlands can reduce flood damage and costs by up to 29 percent in rural areas and 38 percent in urban areas (Douglas McNeil, 2019a).

The benefits of wetlands in reducing flood damage depend both on their physical capacity to reduce flood extent, as well as the value of the assets they protect. Wetlands have the greatest value where they are the most extensive or in front of the greatest assets (Narayan et al., 2017). Even a wetland as small as 2 hectares can retain water runoff from an area 70 times its size, buffering against flooding (Environmental Commissioner of Ontario, 2018b). Wetlands act as important natural buffers against flooding, minimizing damage to infrastructure and communities downstream.

1.2.5 Support of Biodiversity

Although wetlands provide many important ecosystem services that are utilized by humans, they are also critical hotspots for biodiversity conservation, providing habitat for many species, especially birds, amphibians, and reptiles (David Suzuki Foundation, 2008; Tozer et al., 2018). Wetlands are one of the most biodiverse land-cover types on Earth (Medland et al., 2020), and are therefore important for species richness, food chain biodiversity support, and habitat provision. The presence of water, high plant productivity, and other habitat qualities attract high numbers of animal species, many of which depend entirely on wetlands (Zedler & Kercher, 2005b). Habitat loss and fragmentation can disrupt key biological processes by reducing the breeding success of migrant species, limiting dispersal, and decreasing resource acquisition (X. Xu et al., 2018a).

Agricultural expansion and intensification are some of the leading drivers of biodiversity loss globally (Vala et al., 2020), and are often associated with fertilizer and herbicide application, wastewater runoff, and livestock waste (Houlahan & Findlay, 2003). Land use changes due to agricultural expansion and urbanization may result in the reduction or degradation of critical habitat, impede migration among local populations, increase mortality through road kill, and degrade breeding habitat by modifying wetland hydrology (Houlahan & Findlay, 2003).

In Southwestern Ontario, the extensive and dense road network leaves all wildlife species within 1.5 kilometres of a road (Piczak et al., 2019). Species that have large home ranges may be required to cross roads to access habitat for mating or overwintering, leaving them vulnerable to road mortality. Species at risk in Ontario such as reptiles are particularly vulnerable to road mortality as they are slow-moving and spend more time on roads than faster-moving species.

In the Great Lakes Coastal wetlands alone, 30 species of waterfowl, 155 breeding bird species, and 55 species of reptiles and amphibians are supported by wetland habitats. Additionally, nearly all sport and commercial Great Lakes fish species use coastal wetlands for important life-cycle functions (Sierszen et al., 2012). This rich biodiversity being supported by wetlands in Ontario is vitally important to ecosystems at local and global levels, making it a priority to protect Ontario's remaining wetlands.

1.3 Current Wetland Policy in Ontario

Current provincial policies protect wetlands under the Provincial Policy Statement (PPS), the *Conservation Authorities Act*, 1990, and under the *Endangered Species Act*, 2007. Under the Provincial Policy Statement, provincially significant wetlands are protected from development and site alteration in Southern Ontario. The Ontario Wetland Evaluation System's manuals provide the evaluation procedures referred to in the provincial policy statement and are used to determine wetland significance under section 2.1 of the PPS. The PPS provides policy direction on matters of provincial interest related to land use planning and development while protecting resources of provincial interest, and the quality of the natural environment (Schulte-Hostedde et al., 2007). The PPS prohibits “development” and “site alteration” in Provincially Significant Wetlands in Southern and Central Ontario.

Currently, the *Conservation Authorities Act*, 1990, in Ontario provides a legal framework and mandate for Conservation Authorities to take proactive measures to protect, conserve, and manage wetlands. Under section 28 of the Act, Conservation Authorities may restrict and regulate the use of water in or from wetlands. Additionally, they may prohibit, regulate, or require permits for changing or interfering with a wetland and prohibit, regulate, or require permission for development if the control of flooding, erosion, pollution, or the conservation of land may be affected by the development.

Under the *Endangered Species Act*, 2007, destruction or harm of the habitat of endangered and threatened species is prohibited under section 10. This includes habitats critical for the survival, breeding, and feeding of these species. Any proposed activities that may impact wetland habitats of species at risk require assessment and mitigation under the Act.

Federally, wetlands may be protected under the *Impact Assessment Act, 2019*, (IAA) the *Migratory Birds Convention Act*, 1994, (MBCA), and the *Species at Risk Act*, 2002, (SARA). The *IAA* is a federal law that evaluates the potential environmental impacts of proposed projects, including those that could affect wetlands. The Act requires a comprehensive assessment of a project’s potential impacts on various aspects of the environment, including wetlands. The Act also mandates the consideration of alternative locations or designs for projects to minimize environmental impacts. The Act also requires meaningful engagement with Indigenous communities who may be affected by a project, which provides valuable insights into the ecological and cultural significance of wetlands.

SARA prohibits the destruction of the critical habitat of species listed as endangered or threatened. This includes wetland habitats essential for the survival, reproduction, or recovery of these species. Additionally, *SARA* mandates the development of recovery strategies and action plans for endangered and threatened species. These plans may include measures to protect and restore wetland habitats to improve species recovery. A permitting system has also been established under *SARA* for activities that may impact species at risk or their habitats. Permits are required for activities that may alter habitat, include development, or for scientific research.

Under the *MBCA*, destruction, alteration, or disturbance of migratory bird habitat, including wetlands, is prohibited. Under the *MBCA*, the Federal Government can designate migratory bird sanctuaries, including wetlands, to provide additional protection for migratory birds. Like *SARA*, permits are required for activities such as habitat alteration or destruction and scientific research being carried out in Migratory Bird habitats.

At the local level, wetlands may be protected by bylaws and zoning regulations. Zoning bylaws guide municipal official plans by specifying land use regulations, such as development restrictions, to protect wetlands from activities that have the potential to harm wetlands. As previously mentioned, Conservation Authorities also play a significant role in wetland protection. Municipalities often work closely with Conservation Authorities to ensure that development proposals adhere to wetland protection regulations and policies.

1.4 The Ontario Wetland Evaluation System

The Ontario Wetland Evaluation System (OWES) is a methodology used in Ontario to identify wetlands that have value at a provincial scale and will therefore receive provincial protection. The evaluation system was developed based on scientific criteria, to serve the needs of Ontario's planning process that is generally implemented by municipalities. The OWES is a scoring system, which evaluates both ecosystem values and human utility values. Ecosystem values occur in the wetlands itself, or downstream. Ecosystem values include primary production, watershed protection, biodiversity preservation, and natural cycles such as carbon, nitrogen, and water. Human utility values include the social and economic values that wetlands provide to people. These include flood control value, recreational use, and improvement of water quality. The scoring system is grouped into four categories: biological, social, hydrological, and special features.

The biological category evaluates the productivity, biodiversity, and size of the wetland. In this category, the wetland type, soil type, and the number of growing days is evaluated to estimate the value of productivity in the wetland. To evaluate biodiversity in the wetland, the number of wetland types, vegetation communities, and diversity of surrounding habitat is scored. Finally, the size is evaluated, where smaller wetlands generally score less than larger wetlands depending on their biodiversity score.

The social category evaluates the short-term use and amenities that a wetland provides to people, such as economically valuable products, recreational activities, landscape aesthetics, and cultural heritage. Economically valuable products such as plants and animals are evaluated in this category. Products such as peat and sand deposits are not evaluated here, as only sustainable products can be evaluated in this category. This is because harvesting of these products would seriously impact the ecological values of the wetland and result in a loss of human utility value over time. Products such as wood, wild rice, baitfish, and fur-bearing animals are evaluated in this category. Recreational activities such as nature appreciation, hunting, and fishing are an important social value of wetlands. These uses are also evaluated in this category. Landscape aesthetics is also evaluated under the social category as the natural beauty of a wetland holds inherent value to society. To evaluate this, the distinctness of the wetland is scored as well as the absence of human disturbance. Educational use and public awareness of the wetland is also scored in this category. Wetlands that are used by school groups, for research or for the interpretation of nature are scored based on their usage. Finally, Aboriginal, and cultural heritage is evaluated. If the wetland provides Aboriginal and cultural heritage value, the wetland is awarded points in this category.

The hydrological category assesses the role a wetland plays in the maintenance, control, and modification of the quantity and quality of water passing through a drainage basin. This category is meant to determine the net hydrological benefit provided by the wetland to the downstream basin of the wetland. In this category 5 wetland functions are evaluated: 1) flood attenuation, 2) surface water nutrient retention and modification, 3) long-term carbon storage, 4) shoreline erosion control, and 5) groundwater recharge.

Finally, the special features category evaluates the geographical rarity of wetlands, the occurrence of rare species, and habitat quality for wildlife. Under this category, features of the wetland itself are scored, however as many species use different habitats for different purposes, such as foraging and nesting, evaluators need to make note of features present in surrounding lands. After each category has been evaluated individually and independently of the other categories, the scores for each category are then totaled to a maximum of 250 points per category. Overall, a wetland can score a maximum of 1000 points, with wetlands scoring over 600 points overall, or over 200 in the biological or special features categories being evaluated as provincially significant.

In November 2022, the *More Homes Built Faster Act*, *2022*, received royal assent. Under Bill 23, the 4th edition of the Ontario Wetland Evaluation System was published which included three major changes to the previous editions of the OWES. The first major change is that wetlands would no longer be evaluated as complexes. In a wetland complex, major functional discontinuities such as uplands or lakes may subdivide the area into several distinctive wetland units, but the entire wetland area is evaluated as a single unit (DeLoyde & Mabee, 2023). Within the wetland complex, single wetland units are connected functionally. Functional linkages include wildlife usage for migration or feeding, and surface water and groundwater connections.

The second change to the OWES is that no points would be awarded to wetlands that provide reproductive habitat for endangered or threatened species. The third change is that no points would be awarded to the wetlands for providing migration, feeding, or hibernation habitat for endangered or threatened species. Under both the 3rd and 4th editions of the OWES guidelines, wetlands are deemed provincially significant if they score at least 600 points overall, or at least 200 points in either the biological or special features component.

Under the 3rd edition of the OWES in the special features category, wetlands that provide reproductive habitat for endangered or threatened species would automatically be evaluated as provincially significant as they would score 250 points for each endangered or threatened species under the special features category. Additionally, the 3rd edition recognized the importance of wetlands habitat for migration, feeding, and hibernation. Wetlands would score 150 points for one endangered or threatened species using the wetland during migrations, or for feeding or hibernation. Each additional species would award the wetland 75 points. This would mean that a wetland that provides suitable habitat along a migration route for just two species at risk would make the wetland provincially significant.

In the 4th edition of the OWES, species at risk are considered only as "provincially tracked species", which are worth significantly fewer points under the new scoring system. While provincially tracked species still include species at risk under *SARA* and Ontario's *Endangered Species Act*, they only award the wetland 50 points for the presence of one species and up to 176 points for 25 species. Past 25 species, each additional species provides only one additional point. This means that a wetland would need to have 49 provincially tracked species present to score 200 points in the special features category, making it increasingly difficult for a wetland to be deemed provincially significant.

Under both the 3rd and 4th editions of the OWES, wetlands smaller than 2 hectares are generally not evaluated, meaning that small wetlands (those smaller than 2 hectares) do not receive provincially significant status, and are left with little to no legal protection. Under the 3rd edition of the evaluation system, this was not concerning, as small wetlands could be included in larger wetland complexes and be considered part of a provincially significant wetland complex. However, with the new scoring criteria of the 4th edition, wetland complexes can be divided into their individual wetland units and re-evaluated using the new scoring system. This leaves small wetlands vulnerable to losing their provincial protection, and consequently vulnerable to agricultural and urban development.

All wetlands in proximity to development are at risk, however small wetlands that are spatially removed from larger wetland systems are more at risk of destruction due to anthropogenic influences (Penfound & Vaz, 2022a). This study aims to model the change in how wetlands are complexed in the new edition of the OWES across four ecodistricts in Southern Ontario to determine the potential loss of provincially significant wetland area and the potential impacts on ecosystem services provided by these small wetlands.

2.0 Methods

The study area comprises 4 ecodistricts in Southern Ontario (Figure 1.), Kemptville, Essex, Toronto and Grimsby. The State of Ontario's Biodiversity Report (Ontario Biodiversity Council, 2021a) found that these 4 Ecodistricts experienced the most wetland loss between 2000-2015. The Lake Erie-Lake Ontario Ecoregion contains Grimsby, Essex and Toronto Ecodistricts.

The Lake Erie-Lake Ontario Ecoregion is the most heavily urbanized and industrialized area in Ontario and contains several of the province's largest cities, including Toronto, Hamilton, London and Windsor (Ministry of Natural Resources, 2018). Because these four ecodistricts experienced the most historic wetland loss, they were selected for this study to determine the impact of a change in policy in areas of Southern Ontario where wetlands may be most vulnerable to development.

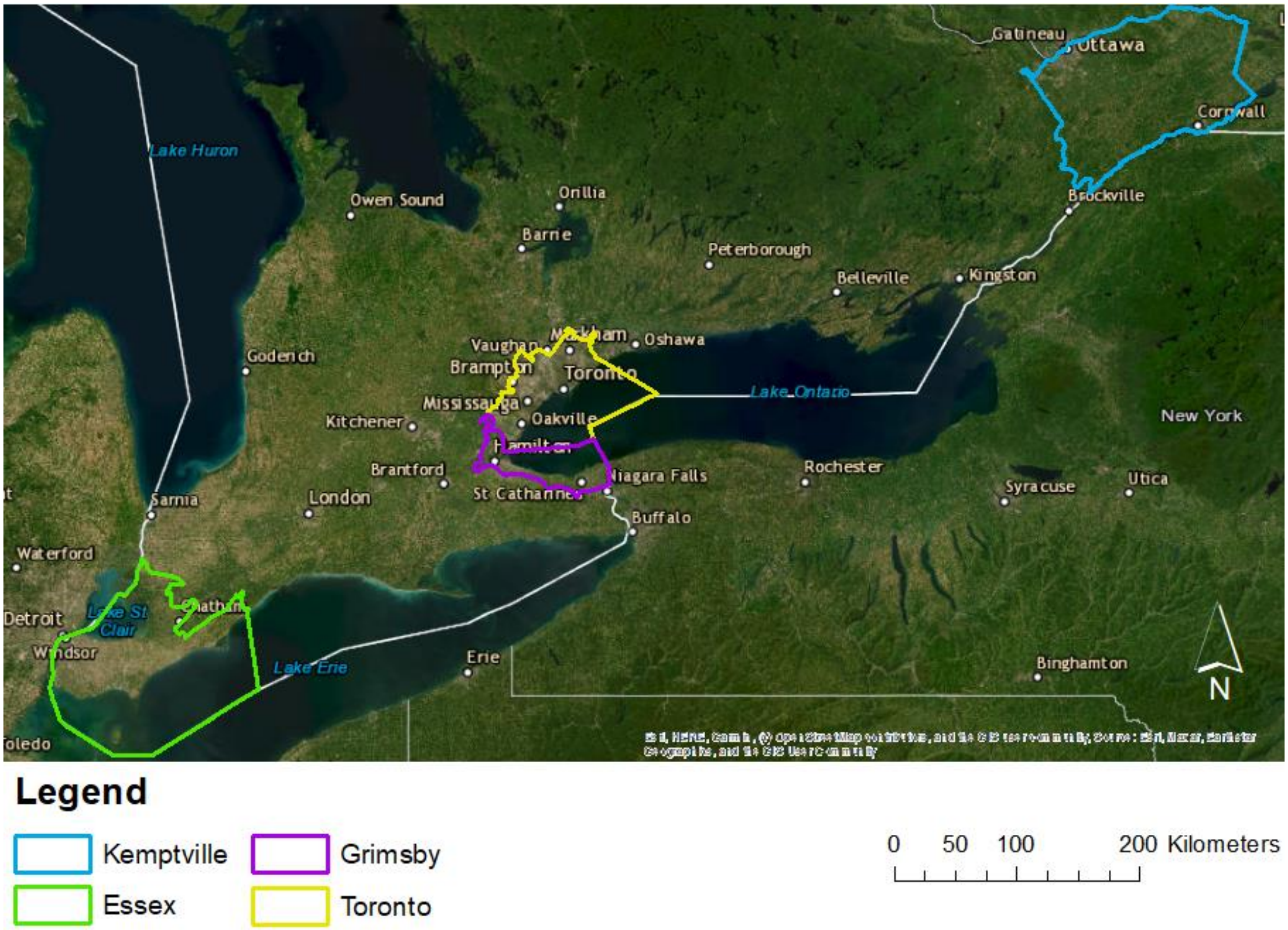

Figure 2. Map of the four Ecodistrict boundaries included in this analysis.

The government of Ontario's GeoHub data was used for their open access to wetland data. Their data set provides a spatial representation and attribute information for Ontario wetlands. The dataset provides information regarding whether the wetland was scored as provincially significant, if it is part of a wetland complex, the area of the entire wetland complex as well as the area of the individual wetland units that make up the complex. For a limited number of evaluated wetlands, the dataset contains the results of the evaluation, where scores are available for the 4 categories used in the evaluation system. Because this information was highly limited, the scores for the evaluated wetlands were not considered in this study.

The OWES data layer contains information for each wetland evaluated in Ontario. The wetland data layer contains a unique identifier ID for each wetland unit and wetland complex evaluated, information about the type of wetland evaluated (bog, fen, marsh or swamp), whether the wetland was evaluated as provincially significant, and the date the wetland was evaluated.

To model the no-complexing change to the Ontario Wetland Evaluation System, the geohub data layer for wetlands was clipped in ArcMap to include only the evaluated wetlands in each ecodistrict. The wetland layer was then manipulated to represent wetlands that were evaluated as provincially significant, and wetlands evaluated as “other” (Figures 2,3,4 & 5).

The area of each individual wetland was then calculated in hectares in ArcMap using the zonal geometry tool. In order to manipulate the wetland data, the wetland attribute tables for each ecodistrict were exported into Excel. In Excel, the unique identification code for each wetland complex was used to filter out wetlands that were not evaluated as wetland complexes. The total area of all provincially significant wetland complexes was then calculated by summing the area of all PSW wetland units. To calculate the predicted area loss of small wetland units after the no-complexing change, a strict cutoff of 2.000 hectares was used to filter out small wetlands from the dataset.

The total area of the provincially significant wetlands greater than 2.000 hectares was then calculated, by summing the areas of the remaining wetland units. To determine the total area of small PSWs lost, the area of PSWs greater than 2.000 hectares was subtracted from the total area of all PSW units. These steps were repeated for each Ecodistrict and then for all of Southern Ontario to provide a larger frame of reference for wetland loss as a consequence of the policy change.

To determine the impacts of the changes to the Ontario Wetland Evaluation System on ecosystem services provided by small wetlands, the value transfer method was applied by multiplying the unit value for different ecosystem services (Table 2.) by the total small wetland surface area lost in each ecodistrict. For the purposes of this study, only market-based ecosystem services were evaluated. This provided an estimate of the annual loss in ecosystem services in each ecodistrict provided by small wetlands. Ecosystem service unit values were averaged from scientific literature and/or publicly available reports that are relevant to Southern Ontario. Phosphorus retention rates were found in a report done by Aziz & Van Cappellen (2021), where they valued phosphorus filtration services of bogs, marshes, and swamps in Southern Ontario (Table 1.). Annual carbon storage values and flood control values were found in a report by the David Suzuki Foundation, (2008). This report summarizes ecosystem services and their annual value for ecosystems in Ontario's Greenbelt. The values in this report represent a conservative estimate as the carbon uptake by wetland plant cover is not included in this value. The original unit values were converted to 2024 Canadian dollars (CAD) values by adjusting for inflation.

Table. 1 Annual Phosphorus retention rates per wetland type.

Wetland Type	Phosphorus Retention Rate[1] (Kg/Ha/Year)
Bog	44.7
Marsh	57.9
Swamp	34.6

[1] Aziz & Van Cappellen (2021)

Table. 2 Annual ecosystem service values provided per hectare of wetland, where Phosphorus removal and Carbon storage values are dependent on the wetland type.

Wetland Type	Phosphorus Removal Value[1] ($/Ha/Year)	Flood Control Value[2,3] ($/Ha/Year)	Carbon Storage Value[2] ($/Ha/Year)
Bog	850	5951.57	486.09
Marsh	1100	5951.57	539.61
Swamp	660	5951.57	429.41

[1] Aziz & Van Cappellen (2021), [2]David Suzuki Foundation, 2008; [3]DeLoyde & Mabee, 2023

3.1 Anticipated Wetland Loss

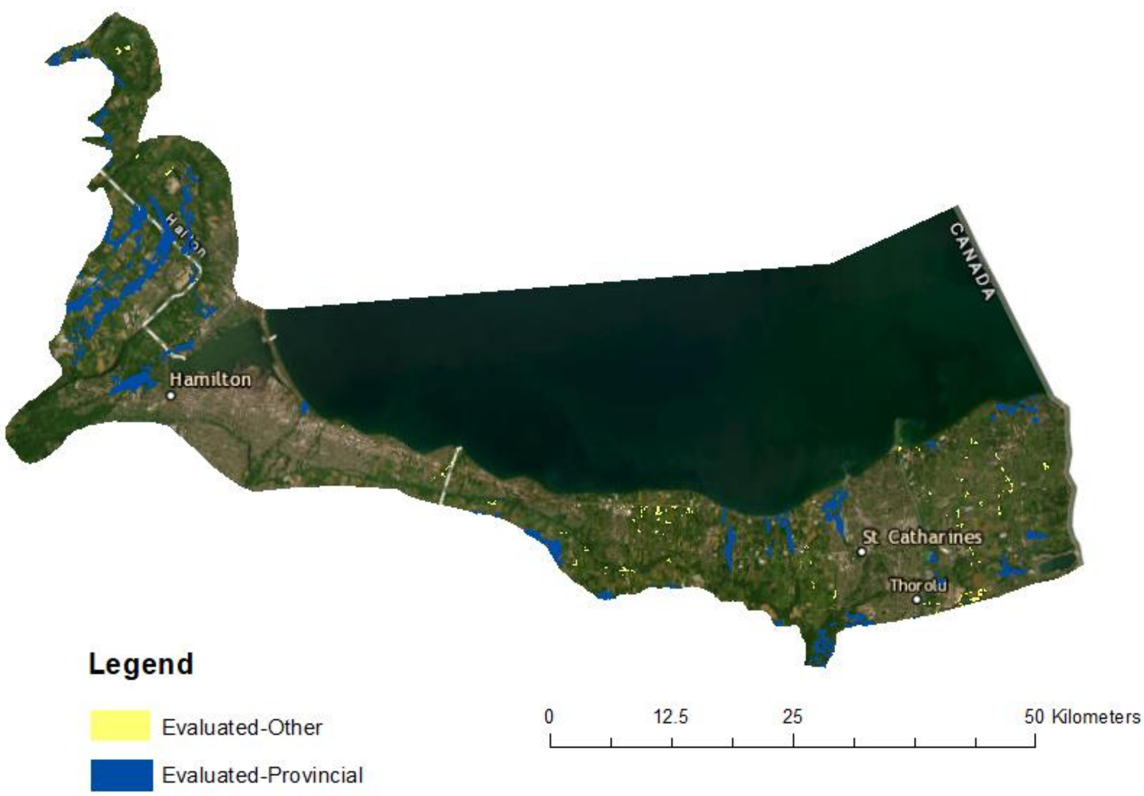

Figure 3. Map of evaluated wetlands in Grimsby Ecodistrict prior to the 2022 changes to the OWES. Wetlands evaluated as provincially significant are shown in blue, other evaluated wetlands are shown in yellow.

The Ecodistrict of Grimsby contains 693 evaluated wetlands, of which 571 (82.3%) have been designated as provincially significant (Figure 2.). In Grimsby, 675 wetlands were evaluated as complexes making up 54 wetland complexes of which 33 were designated as provincially significant. Figure 2. is representative of how larger wetlands that are evaluated as complexes are generally scored as provincially significant, whereas the smaller isolated wetlands are designated as “other”.

Figure 2. also shows that there is only one remaining wetland within the urban area in the city of Hamilton bordering Lake Ontario. Additionally, in the urban areas of Hamilton and St. Catharines, there are very few non-provincially significant wetlands remaining, whereas in the rural areas, few small isolated non-PSW wetlands can be seen. Larger wetland complexes can be seen in the north-west region of Hamilton in the Burlington Canal-Hamilton Harbour watershed, which overlaps with multiple conservation areas. PSW complexes can also be seen along the shore of Lake Ontario forming large marsh complexes.

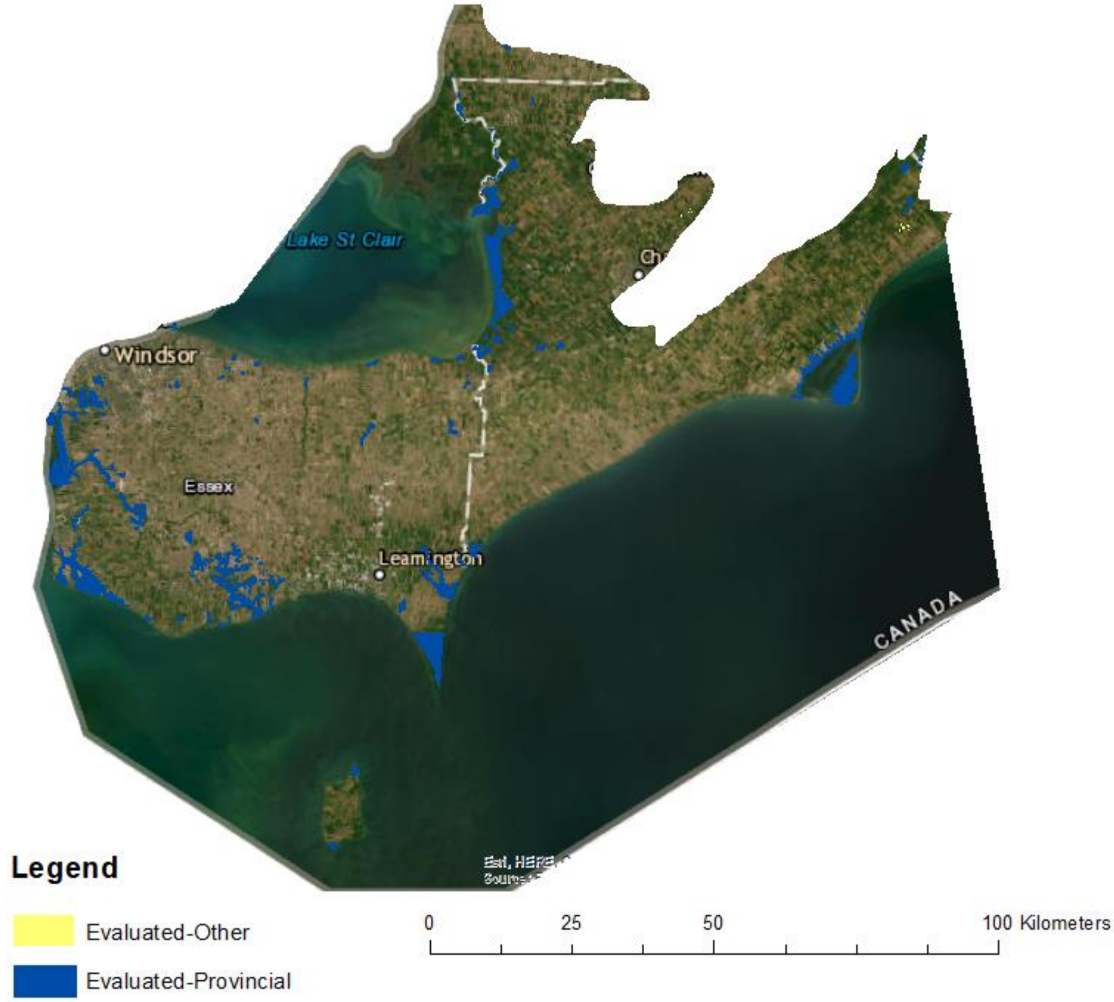

Figure 4. Map of evaluated wetlands in Essex ecodistrict prior to the 2022 changes to the OWES. Wetlands evaluated as provincially significant are shown in blue, other evaluated wetlands are shown in yellow.

The Ecodistrict of Essex contains 2358 evaluated wetlands, of which 2315 (98.18%) have been designated as provincially significant (Figure 3.). In the Ecodistrict of Essex, 2357 wetlands were evaluated as complexes making up 69 wetland complexes of which 65 were designated as provincially significant. Figure 3. shows that very few wetlands without provincially significant designation remain in Essex, likely because the majority of the ecodistrict's unprotected wetlands have been converted into agricultural fields or urban areas.

Like Grimsby, most provincially significant wetlands in Essex are found near larger bodies of water: Lake Erie to the South, Lake St. Clair to the North and the Detroit River to the West, which provide municipal drinking water to the Essex region. Larger marsh complexes occur along the north end of Lake St. Clair, south of the community of Leamington and east of the community of Shrewsbury (found towards the right side of the map).

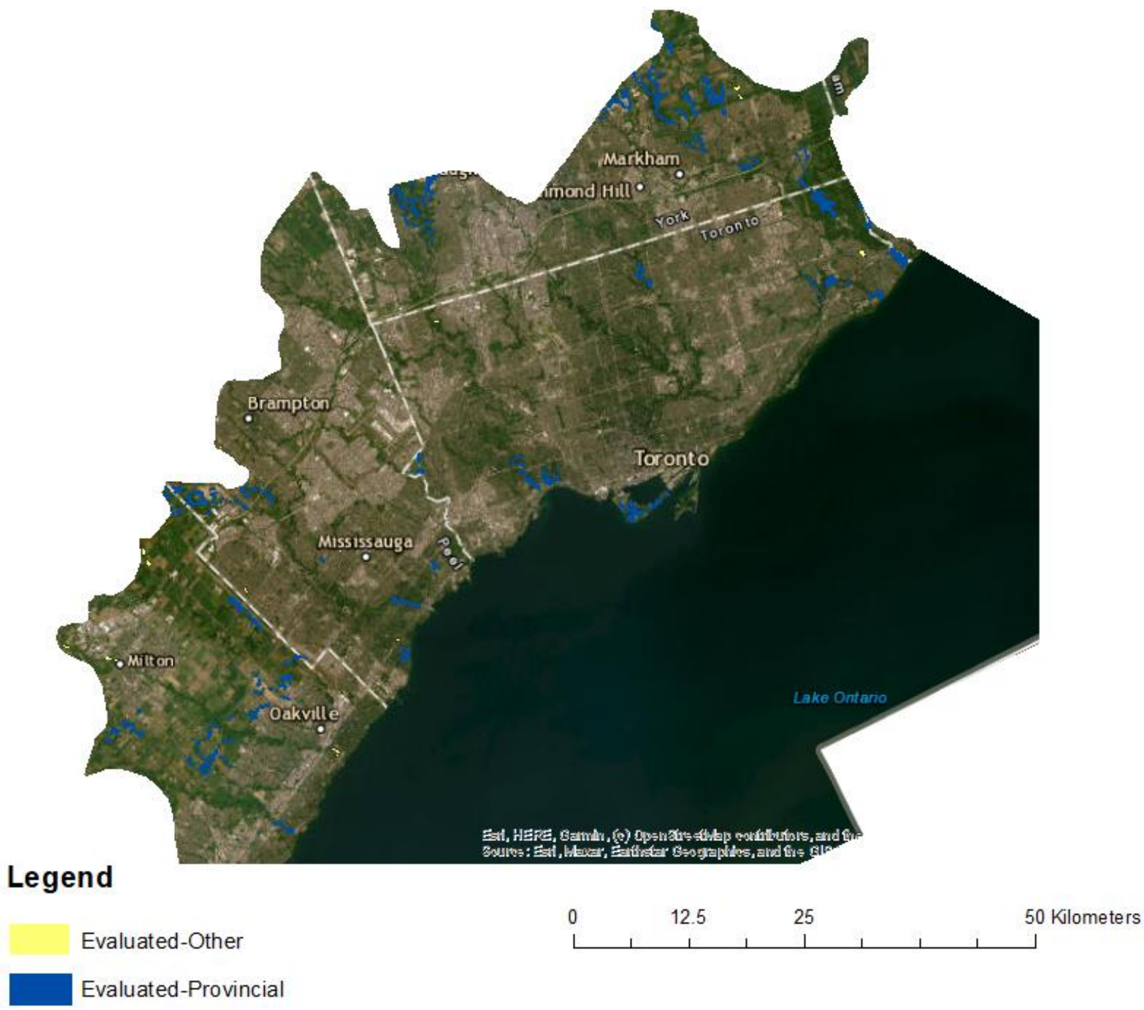

Figure 5. Map of evaluated wetlands in Toronto Ecodistrict prior to the 2022 changes to the OWES. Wetlands evaluated as provincially significant are shown in blue, other evaluated wetlands are shown in yellow.

The ecodistrict of Toronto contains 1752 evaluated wetlands, of which 1701 (97.1%) have been designated as provincially significant (Figure 4.). In the Ecodistrict of Toronto, 2357 wetlands were evaluated as complexes making up 40 wetland complexes of which 31 were designated as provincially significant. Similarly to Essex, very few wetlands without provincially significant status remain intact. 52% of the Ecodistrict, the highest proportion for Ontario, has been altered to support settlement and associated infrastructure, leaving less than 1% of the area designated as a protected area (Ontario Biodiversity Council, 2021b).

Major PSW complexes occur in the Rouge River watershed along the eastern boundary of the Ecodistrict, as well as in the Sixteen Mile Creek watershed along the south-western boundary. In heavily urbanized areas, PSWs occur in parks and along recreational areas such as High Park in Downtown Toronto as well as on the Toronto Islands.

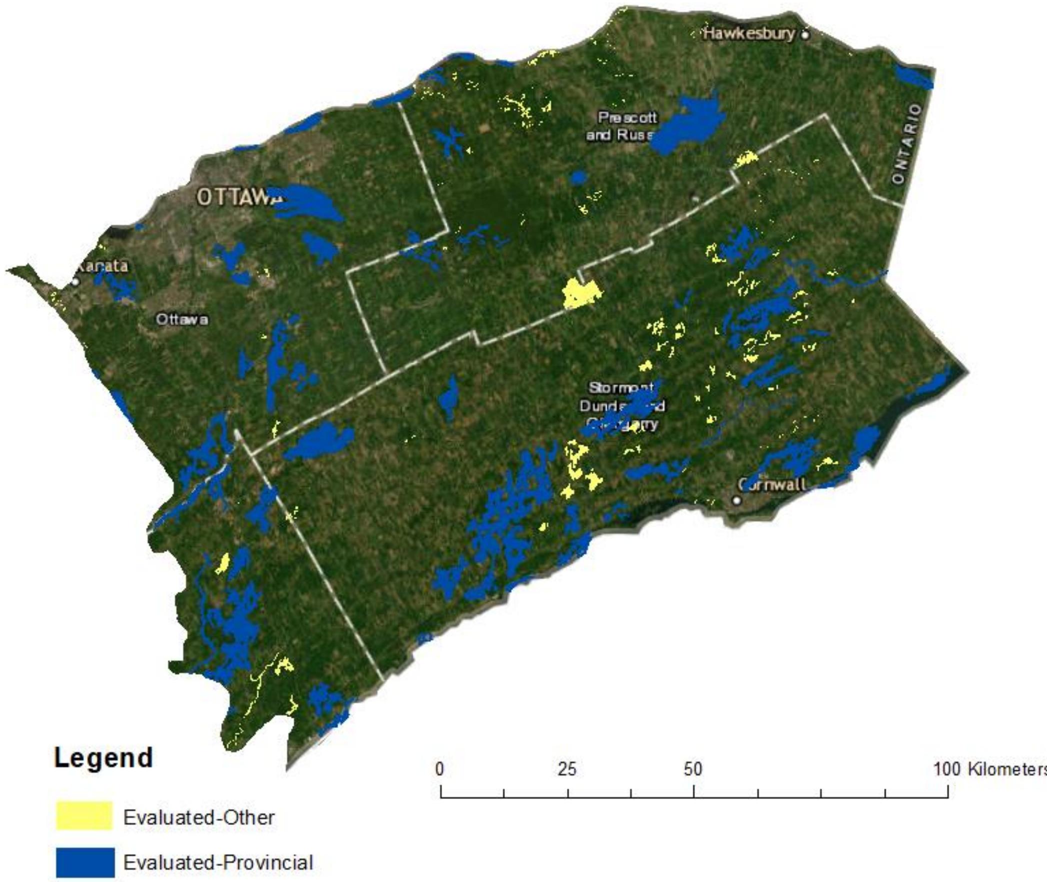

Figure 6. Map of evaluated wetlands in Kemptville Ecodistrict prior to the 2022 changes to the OWES. Wetlands evaluated as provincially significant are shown in blue, other evaluated wetlands are shown in yellow.

The Ecodistrict of Kemptville contains 4918 evaluated wetlands, of which 3556 (72.31%) have been designated as provincially significant (Figure 5.). In the Ecodistrict of Kemptville, 4914 wetlands were evaluated as complexes making up 162 wetland complexes of which 157 were designated as provincially significant.

Of the 4 Ecodistricts included in this study, Kemptville has the highest proportion of remaining wetlands without provincially significant status. Although Kemptville has retained many of it’s non-PSWs, this Ecodistrict has experienced the highest percentage of wetland area loss in all of Southern Ontario.

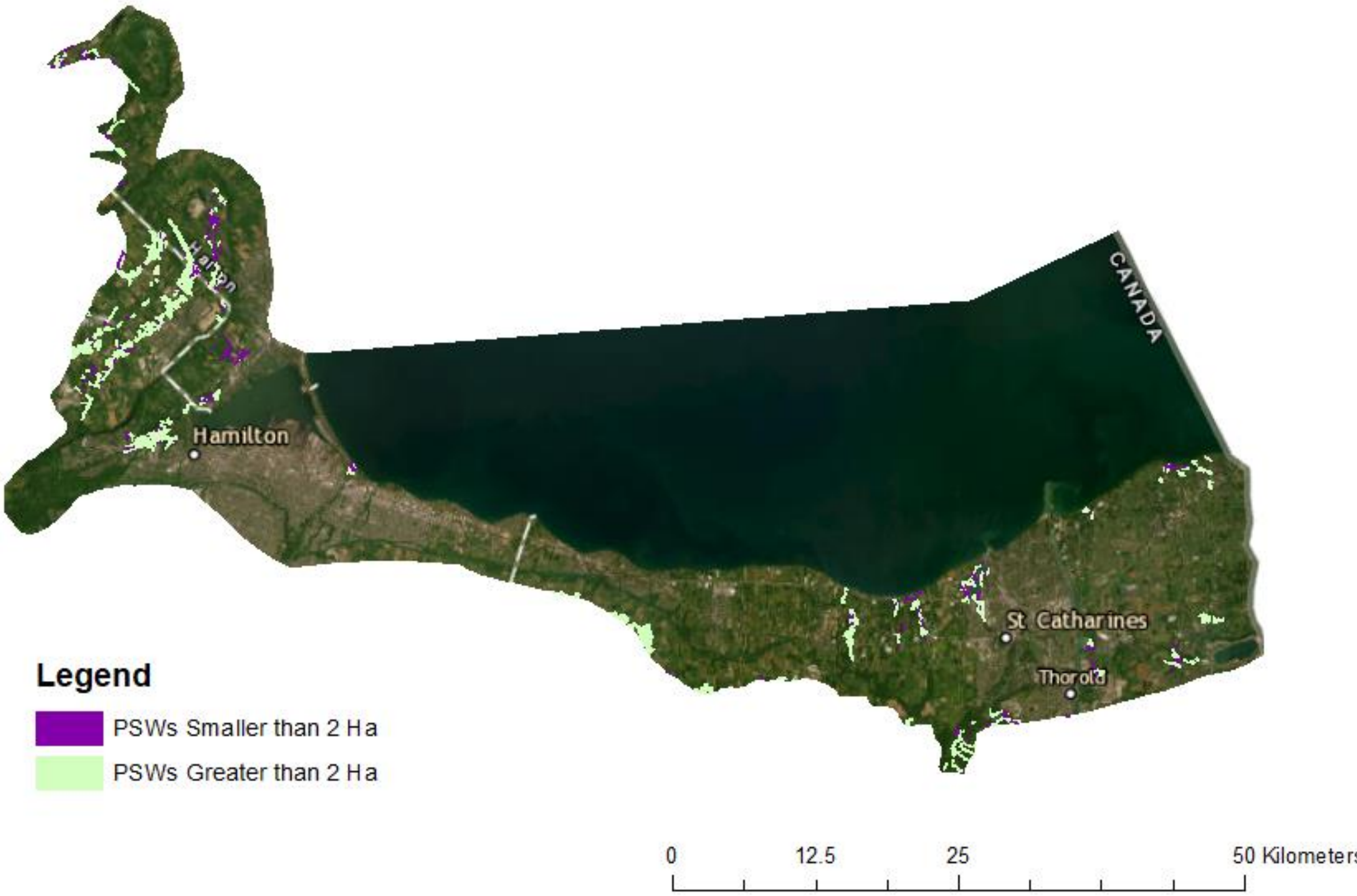

Figure 7. Map of predicted loss of wetlands smaller than 2 hectares in Grimsby ecodistrict. Wetlands shown in purple are predicted to be lost.

After excluding small wetland untis in the ecodistrict of Grimsby, 278 wetlands would no longer be evaluated under the new OWES. These 278 wetlands equate to 213.23 hectares of wetland area, which would result in a 6.8% loss in wetland area. The majority of the predicted wetland loss occurs on the edges of major wetland complexes along the shoreline of Lake Ontario as well as in the north-west region of Hamilton in the Burlington Canal-Hamilton Harbour watershed. In the north-west region of the map, an entire wetland complex made up of 39 individual wetland units is predicted to be lost as each wetland unit is smaller than 2 hectares.

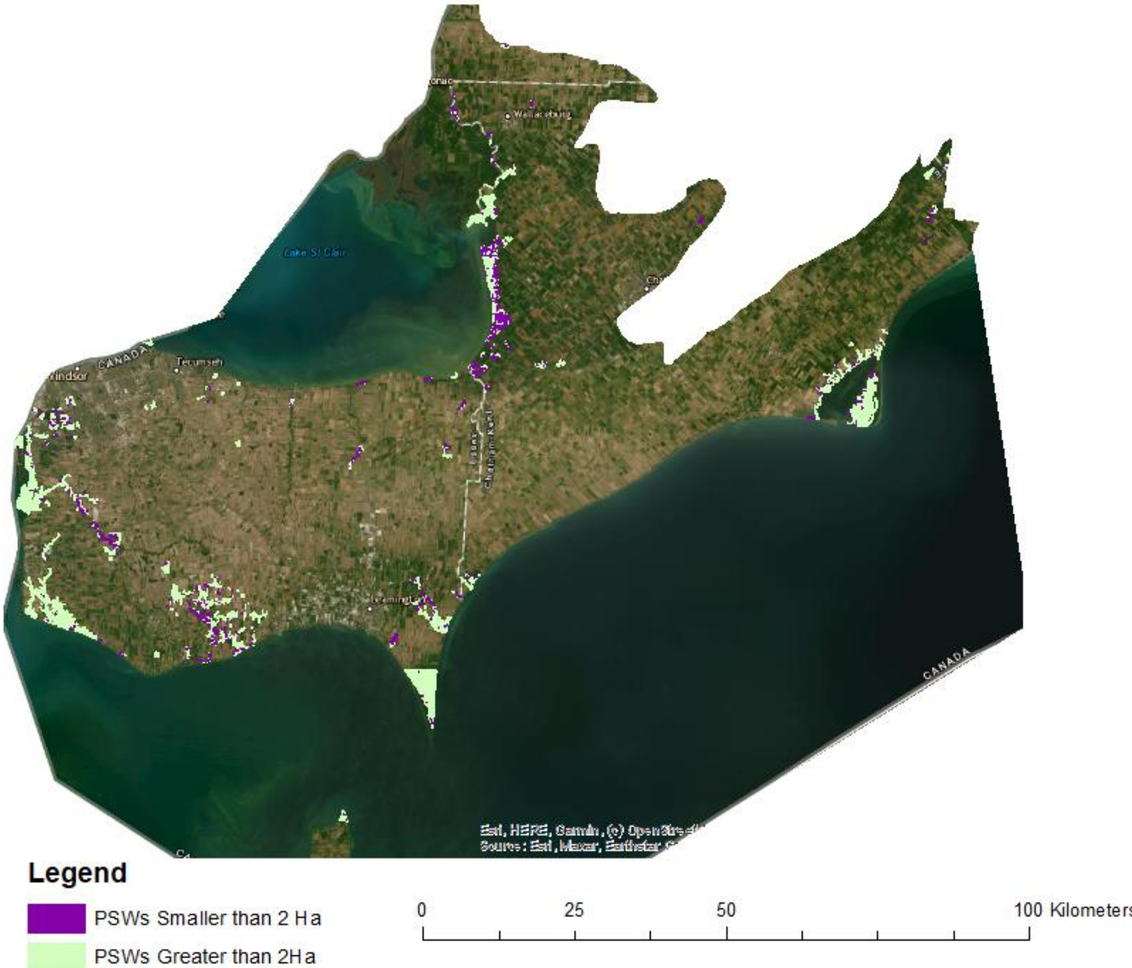

Figure 8. Predicted loss of wetlands smaller than 2 hectares in Essex ecodistrict. Wetlands shown in purple are predicted to be lost.

After excluding small wetlands in the ecodistrict of Essex, 1284 wetlands would no longer be evaluated under the new OWES. These 1284 wetlands equate to 956.6 hectares of wetland area, resulting in a 5.6% loss in wetland area. Similar to Grimsby ecodistrict, a large part of wetland loss is smaller individual wetland units bordering larger wetland complexes. A significant amount of loss is seen along the shore of Lake St. Clair, where entire complexes are predicted to be lost. Additionally, along the shore of Lake St. Clair a significant portion of the predicted loss of small wetland units occur in buffer zones berween the coastal wetlands and the agricultural fields to the east. Other signifcant loss can be seen in the south-western region, where small individual wetland units border larger complexes.

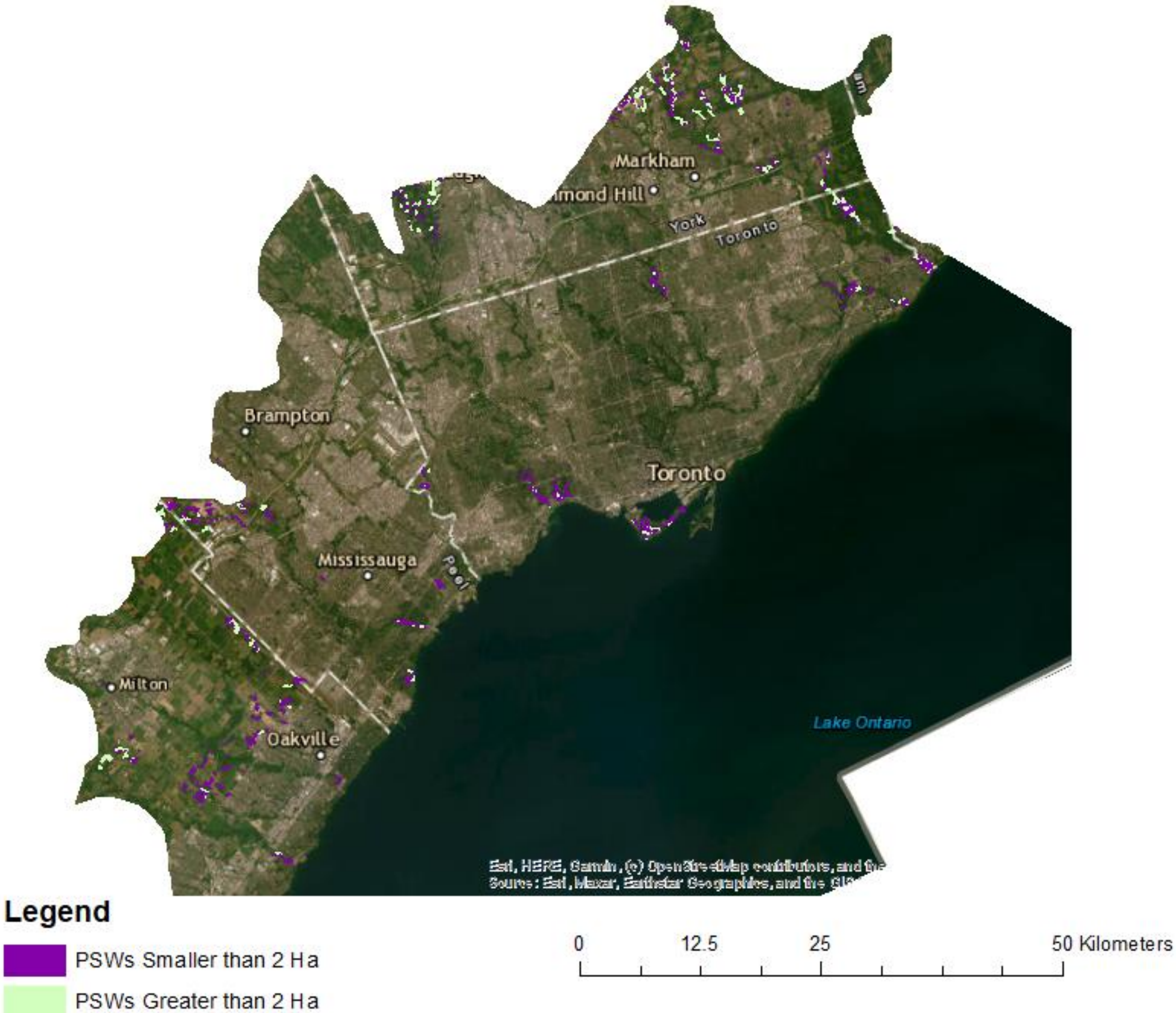

Figure 9. Predicted loss of wetlands smaller than 2 hectares in Toronto ecodistrict. Wetlands shown in purple are predicted to be lost.

In Toronto, 1478 small wetland units would no longer be evaluated under the new OWES. These 1478 wetlands equate to 672.24 hectares of wetland area, resulting in a 37.9% loss in wetland area, the highest calculated loss out of the 4 ecodistricts. Almost every wetland complex in this ecodistrict is predicted to experience loss of smaller individual wetland units.

Signficant predicted loss can be seen near the shore of lake Ontario, in the Toronto Islands wetland complex. Other significant loss can be seen in urban parks and along creeks and rivers in the urban area. Due to the heavily urbanized landscape of Toronto, very few large wetland units remain. Many of remaining large wetlands are bordered by smaller wetland units, whichare predicted to lose their provincial protections, indicating that the larger wetland units may become further isolated in the future.

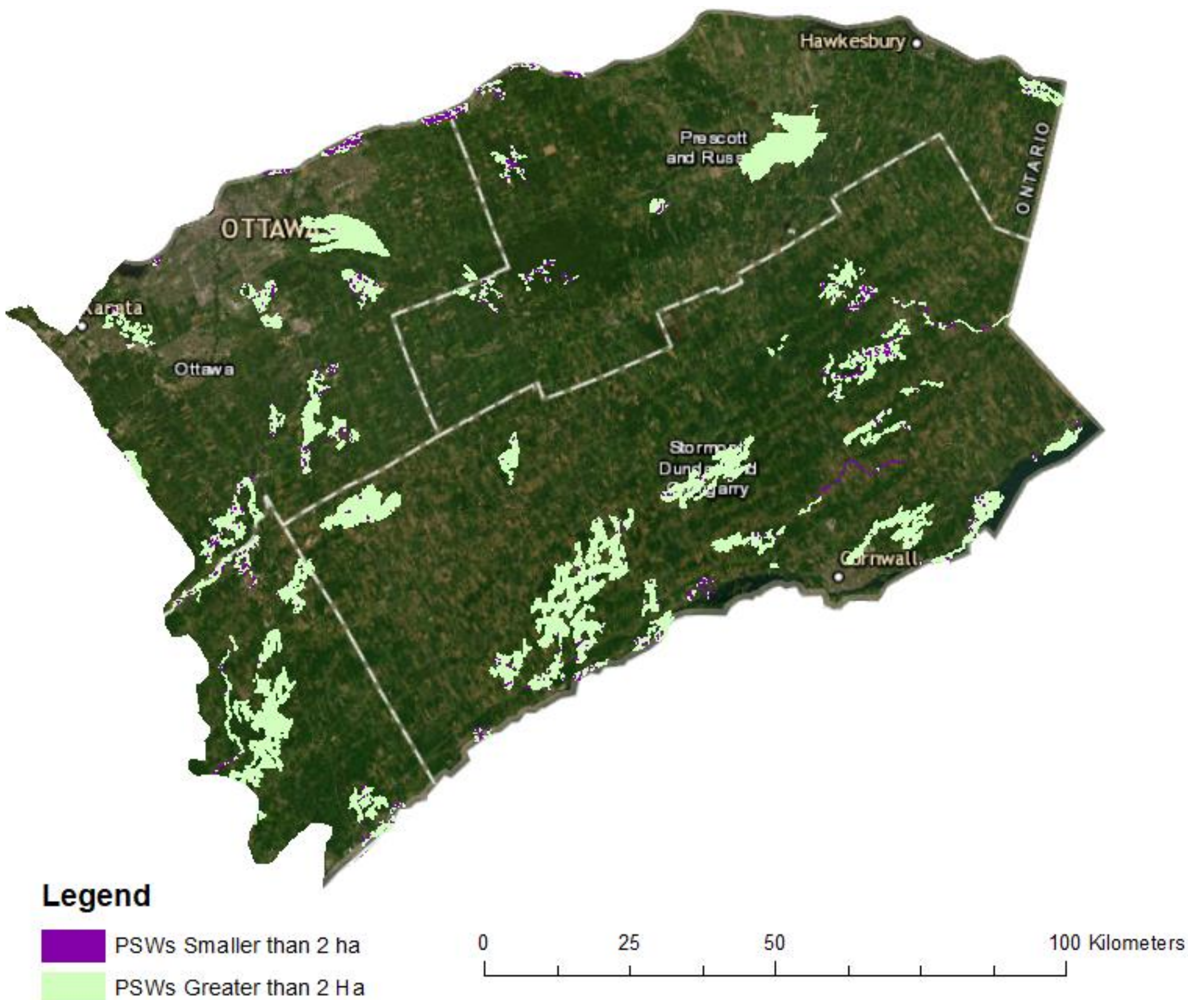

Figure 10. Predicted loss of wetlands smaller than 2 hectares in Kemptville ecodistrict. Wetlands shown in purple are predicted to be lost.

In the ecodistrict of Kemptville, 1008 small wetland units would no longer be evaluated under the new OWES. These 1008 wetlands equate to 999.41 hectares of wetland area, resulting in a 1.3% loss in wetland area, the lowest calculated loss out of the 4 ecodistricts. The Ecodistrict of Kemptville is predicted to retain the most PSW area out of the 4 ecodsitricts, likely because it is less subject to intense urbanization and agricultural conversion. The most significant wetland loss is seen in the southern region, north of Cornwall, where almost an entire wetland complex is predicted to be lost. Significant area is also predicted to be lost along the Ottawa river east of Ottawa, where small wetlands border the river, and make up larger wetland complexes.

Table 3. Summary of results of the wetland "re-evaluation" model for each Ecodistrict. Maintained Provincially Significant Wetlands (PSWs) are wetlands that retain their PSW status after "re-evaluation". PSWs lost are wetlands that are predicted to lose their PSW status after re-evaluation.

Ecodistrict	# Evaluated Wetlands	# PSWs	Area of PSWs (Ha)	# Maintained PSWs > 2 Ha	Area of Maintained PSWs (Ha)	# PSWs Lost	Area of Lost PSWs (Ha)	% PSW Area lost
Essex	2358	2315	17188.40	1031	16222.8	1284	965.59	5.6
Grimsby	693	571	3154.96	293	2941.73	278	213.23	6.8
Toronto	1752	1701	1774.21	223	1101.98	1478	672.24	37.9
Kemptville	4918	3556	77705.32	2548	76705.92	1008	999.41	1.3
Southern Ontario	71779	63113	902389.21	36317	879888.45	35462	22500.76	2.5

3.2 Anticipated Ecosystem Service Impacts

3.2.1 Water filtration impacts

Table 4. Predicted annual loss of water filtration value in Kemptville Ecodistrict.

	Bog	Marsh	Swamp	Total Value Lost ($/year)
PSW Area Lost (Ha)	13.79	605.65	850	
P retention value ($/year)	11,721.5	666,215	518,410	1,196,346

Table 5. Predicted annual loss of water filtration value in Grimsby Ecodistrict.

	Marsh	Swamp	Total Value Lost ($/year)
PSW Area Lost (Ha)	100.29	107.85	
P retention value ($/year)	110,319	71,179	181,499

Table 6. Predicted annual loss of water filtration value in Toronto Ecodistrict.

	Marsh	Swamp	Total Value Lost ($/year)
PSW Area Lost (Ha)	336.86	289.83	
P retention value ($/year)	370,548	191,286	561,835

Table 7. Predicted annual loss of water filtration value in Essex Ecodistrict.

	Marsh	Swamp	Total Value Lost ($/year)
PSW Area Lost (Ha)	576.05	386.57	
P retention value ($/year)	633,653	255,133	888,787

Phosphorus retention values were found in a report by Aziz & Van Cappellen (2021). Bogs are estimated to have a phosphorus retention rate of 44.7kg/ha/year with a value of 850 ± 885$/ha/year. They estimate marshes to have a phosphorus retention rate of 57.9 ± 42kg/ha/year with a value of 1100 ± 1105$/ha/year. Swamps were estimated to have a phosphorus retention rate of 34.6 ± 21kg/ha/year with a value of 660 ± 600$/ha/year.

In the Ecodistrict of Kemptville, this model predicts a loss of $1,196,346.2 in phosphorus retention services (Table 2.). In the Ecodistrict of Grimsby, a loss of $181,499 in phosphorus retention services annually (table 3.). In the Ecodistrict of Essex a loss of $888,787 in phosphorus retention services annually (table 4.) In the Ecodistrict of Toronto, a loss of $561,835 in phosphorus retention services annually (table 5.).

3.2.2 Flood Control Impacts

Table 8. Estimated annual flood control value lost per Ecodistrict after re-evaluation model. Flood control value was estimated at 5951.57$/Ha/year from literature[1,2]

Ecodistrict	Area of Lost PSWs (Ha)	Flood control value ($/Ha/Year)
Kemptville	999.41	4,036,606
Essex	965.60	3,900,056
Grimsby	213.23	861,242
Toronto	672.24	2,715,163

[1]David Suzuki Foundation, 2008; [2]DeLoyde & Mabee, 2023

Using a valuation of 6951.57$/Ha/year, Kemptville is predicted to have the greatest loss of flood control value as this Ecodistrict is predicted to lose the most wetland area overall (Table x). Essex will experience the second greatest loss, followed by Toronto then Grimsby. In total this would result in a loss of $11,513,067 annually across the 4 Ecodistricts.

3.2.3 Carbon Sequestration impacts

Table 9. Estimated annual carbon storage value lost per Ecodistrict. Carbon storage value was estimated at $486.09/Ha/year for bogs, $539.61/Ha/year for marshes and $429.41/Ha/year for swamps from a report[1]

Ecodistrict	Wetland Type	Area of Lost PSWs (Ha)	Carbon Storage Value ($/Ha/Year)
Kemptville	Bog	13.79	6,703
	Marsh	605.65	326,814
	Swamp	785.47	337,288
Essex	Marsh	576.05	310,841
	Swamp	386.57	165,995
Grimsby	Marsh	100.29	54,117
	Swamp	107.85	46,310
Toronto	Marsh	336.86	181,774
	Swamp	289.83	124,455

[1]David Suzuki Foundation, 2008

Kemptville is predicted to experience the greatest loss of annual carbon storage with an estimate of $670,806/Ha/year, followed by $476,837/Ha/year in Essex, $306,229/Ha/year in Toronto and $100,428/Ha/year in Grimsby. Kemptville is the only Ecodistrict which is expected to lose wetland area from Bogs, which are important peatlands.

4.0 Discussion

4.1 Small wetland area loss

Across the four ecodistricts, it is predicted that Toronto would experience the highest percentage of small wetland loss. It was estimated that Toronto would lose 37.9% of it's small wetland area. This is likely because of Toronto's highly urbanized landscape, leaving any remaining wetlands smaller than 2 hectares. In the most urbanized areas, the remaining wetland complexes are almost entirely made up of small wetlands. Even in the surrounding Greater Toronto Area, cities like Oakville and Mississauga are also expected to lose significant wetland areas due to the complexing of many small wetlands.

This significant wetland loss may have a particularly negative impact on this area due to the risk of flooding. Many of the small wetlands border rivers and Lake Ontario, where water levels have risen in the past resulting in extreme flooding. The loss of these wetlands would likely result in higher flood risk for certain areas.

Grimsby and Essex are predicted to experience about 6% of small wetland area loss. This percentage is likely lower because they both have larger wetland complexes made up of large wetland units. The smaller wetlands that are expected to lose their provincial protections are mostly bordering large wetland complexes or act as buffer zones along the large lakes in the Area. Like Toronto, very few wetlands remain in the highly urbanized areas of Grimsby and Essex.

Kemptville was predicted to experience the lowest percentage of small wetland area loss overall with a loss of only 1.9%. This is likely because the area experiences significantly less urbanization and agricultural development which can leave large wetlands fragmented and divided into smaller parts. The wetland complexes found in Kemptville are made up of large wetland units, and only a few complexes contain wetland units smaller than 2 hectares. The most significant loss was predicted to be along the Ottawa River, east of the city of Ottawa, and north of Cornwall, where a wetland complex borders a smaller river. The Ottawa River has experienced elevated water levels in the past, most recently in 2017, where parts of the City of Ottawa and the City of Gatineau experienced flooding. Loss of these small wetland units may result in higher risks of flooding in areas that border rivers.

Kemptville is also home to unique ecosystems for Southern Ontario. Two of Ontario's largest wetland complexes south of the Canadian Shield occur in Kemptville. The Mer Bleu and Alfred Bog are dominated by bog and fen wetland complexes, which are normally not found this far south. Because of their large size, and unique ecosystem features, these wetland complexes were protected by the federal government in the mid-1950s to preserve them for recreational and scientific use. Because of the lack of exploitation and development, these wetland complexes remain unfragmented and were evaluated as larger wetland units, allowing them to maintain their PSW status.

Overall, the wetland loss model indicates a significant amount of small wetland loss across Southern Ontario. If left unprotected, these small wetlands will be vulnerable to urban and agricultural development, resulting in further fragmented and isolated wetland complexes. For this reason, decision-makers need to consider all of the benefits and services wetlands provide. By understanding the economic value of ecosystem services, decision-makers can better weigh the costs and benefits of different actions impacting wetland ecosystems.

4.2 Phosphorus Removal Impacts

This study estimates that small wetlands (wetlands smaller than 2 hectares) across the 4 study sites provide approximately $2,828,467/year in phosphorus removal services (Tables 2,3,4 & 5). To determine if the phosphorus removal service provided by wetlands is cost-effective in comparison to implementing phosphorus removal alternatives, values obtained from Aziz & Van Cappellen (2021) were used to compare the annual cost of offsetting phosphorus removal from 1 ha of lost wetland to the overall phosphorus removal provided by small wetlands across the 4 Ecodistricts. They calculated how much it would cost to replace the existing phosphorus filtration function of wetlands using three alternative human-engineered solutions. Human-engineered solutions include implementation of best management practices (BMPs), constructed wetlands, and using water treatment plants to filter phosphorus.

Phosphorus BMPs may include applying phosphorus fertilizers only where needed and incorporating or applying it below the soil surface to prevent phosphorus from leaving agricultural fields through water and wind erosion. Erosion control BMPs focus on reducing field runoff. No-till farming, installation of water control structures, and strip cropping can reduce soil erosion, consequently reducing the amount of phosphorus in receiving rivers and lakes. The value of implementing BMPs in 2024 is approximately $20,100/year to offset excess phosphorus from the loss of 1 hectare of wetland (Aziz & Van Cappellen, 2021). This would result in a cost of $57,294,447 annually to implement BMPs to offset the cost of losing all PSWs smaller than 2 hectares across all four Ecodistricts.

Constructed wetlands can be designed and implemented to specifically target phosphorus removal from human and agricultural waste (David Suzuki Foundation, 2008). These engineered wetlands can be customized to enhance nutrient uptake through the selection of appropriate plant species and water flow dynamics. The value of implementing constructed wetlands in 2024 is approximately $4,300/year to offset excess phosphorus from loss of 1 hectare of wetland.

Finally, waste water treatment plant upgrades may include implementing chemical treatment processes to enhance phosphorus removal, enhancing primary treatment processes to remove particulate phosphorus, or implementing membrane filtration technologies to capture phosphorus from wastewater. The value of implementing waster water treatment plant upgrades in 2024 is approximately $729,667/year to offset excess phosphorus from the loss of 1 hectare of wetland. These results from Aziz & Van Cappellen (2021) indicate that the alternative options for phosphorus removal are not cost-effective when compared to the phosphorus retention service values of the existing wetlands.

4.3 Flood Control Impacts

This study estimates that small wetlands across the 4 Ecodistricts provide $11,513,067 annually in flood control value, with the greatest losses in Kemptville and Essex. In Kemptville, the Rideau Valley Conservation Authority has identified multiple flood-vulnerable areas along the Rideau River, the Jock River, Stevens Creek, Kemptville Creek and the Tay River. Many small wetlands along the Rideau River near the town of Smith's Falls are predicted to be lost, likely increasing the risk of floods in the area due to a decrease in floodplain area. Similarly, small wetlands along Kemptville Creek and Stevens Creek are expected to be lost further contributing to flood risks in the area.

Essex is surrounded on three sides by water, with Lake Ontario to the South, the Detroit River to the West and Lake St. Clair to the North. This makes Essex vulnerable when water levels rise in the Great Lakes and during severe weather events. Many of the flood-prone areas, mainly along the shore of lake St. Clair and in the south-western region near the towns of Kingsville and Harrow overlap with areas that are predicted to lose significant area of small wetlands.

As previously mentioned, the Toronto Islands wetland complex is predicted to experience significant loss of small wetland area. In recent years the Toronto Islands have experienced severe flooding due to water levels rising in Lake Ontario. In the Spring of 2017, water levels in Lake Ontario reached levels higher than had been measured since record-keeping began in 1918 (Toronto and Region Conservation Authority, 2019). The 2017 high water levels were the result of extreme wet weather in the Lake Ontario basin, record inflows from Lake Erie, and reduced outflow capacity due to downstream flooding on the St. Lawrence and Ottawa rivers. Additionally, watersheds within the City of Toronto tend to be relatively small, with short stream lengths and highly urbanized and impervious surfaces, leaving little lead time between rainfall and flood impacts (Douglas McNeil, 2019b). The sustained period of high water levels resulted in approximately $8M in direct and indirect damages to the City of Toronto related to the closing of Toronto Island Park (Wiebe, 2019). Further loss of small wetlands that are part of the Toronto Islands wetland complex would likely lead to more extensive flood damages. Overall, conserving all remaining wetlands may be a cost-effective measure against the risks of flooding across Southern Ontario, especially in high flood risk areas.

4.4 Carbon Storage and Climate Regulation Impacts

The annual carbon storage value of small wetlands across the 4 Ecodistricts was estimated to be $1,554,297, with the highest annual value in Kemptville due to the significant amount of wetland area predicted to be lost.

Although wetlands can be important carbon stores, they also contribute more than 10% of the annual global emissions of methane, an important greenhouse gas (Zedler & Kercher, 2005a). However, the carbon sequestration capacity of wetlands often outweighs their methane emissions under the right conditions. Some studies warn that the destruction of a pristine wetland would emit more carbon from the decomposition of the soil and vegetation carbon pools than 175-500 years of methane emissions from the same wetland (Mitra et. al, 2005). For this reason, existing wetlands need to be preserved to the greatest extent possible to prevent further releases of terrestrial carbon into the atmosphere.

To determine the cost of protecting wetlands from degradation concerning carbon storage, the cost of alternative carbon capture and storage methods must be estimated. Carbon capture and storage costs depend on the process type, capture technology, carbon dioxide transport, and storage location. According to the International Institute for Sustainable Development, CO_2 capture costs are projected to range from $27-48/tCO2 for processes with concentrated CO_2 streams to $50-150/tCO2 for diluted gas streams (Cameron et al., 2023). It is important to note that these values are predominately based on modeling studies, given the limited number of operational carbon capture and storage facilities, and likely do not represent the full costs associated with direct carbon capture and storage. Although artificial carbon capture can be expensive compared to a wetland's natural ability, it is important to consider the costs associated with preserving or restoring wetlands to ensure they remain carbon sinks instead of sources.

As previously mentioned, wetlands can help to regulate climate through carbon storage. These ecosystems provide large terrestrial banks of carbon and prevent increases in the level of greenhouse gases in the atmosphere, leading to increases in global temperature. Because they act as large carbon banks, the degradation of wetlands through drainage to convert them to agriculture allows soil organic matter to be oxidized and release CO_2 into the atmosphere (Erwin, 2009).

Additionally, the reduction of surface water and vegetation, and the increase in impervious surfaces in cities can alter microclimates, causing urban areas to experience higher air temperatures relative to nonurban areas, known as the urban heat island effect (UHI) (Christina P. Wong et al., 2017). This UHI effect may be cause for concern as it may increase the intensity and frequency of heat waves, leading to heat stroke, heat exhaustion and increased mortality.

Although Kemptville is expected to experience the greatest loss of wetland area, urban areas in Toronto may be most at risk of UHI effects. Toronto is centered in the warmest climatic zone in Canada and experienced above-average temperatures in six of seven summers between 2004-2011 (Environment Canada 2010. As a highly urbanized area, Toronto is subjected to UHI effects and is predicted to have double heat-related mortality by 2050 (Vanos et al., 2012). Further wetland loss predicted by the model is likely to contribute to more frequent and intense heat events across all ecodistricts.

4.5 Biodiversity Impacts

2,850.47 Ha of small wetlands are expected to lose their provincial protection across the four Ecodistricts after the changes to the OWES, leaving them vulnerable to development and agricultural expansion. Small wetlands on their own make up a relatively small portion of the total wetland area, however, they may make up a large number of wetlands which play an important role in reducing isolation of larger wetlands. Habitat loss and fragmentation can disrupt key biological processes by reducing the breeding success of migratory species, limiting dispersal, and decreasing resource acquisition (X. Xu et al., 2018b). These small wetlands provide important patches of connectivity throughout wetlands complexes, allowing species to migrate and disperse safely throughout the wetland complex. The loss of small, protected wetlands will likely have negative impacts on the biodiversity supported by wetlands.

Within the Ecodistrict of Grimsby, Cootes Paradise is home to the largest PSW complex on Western Lake Ontario and has the highest floristic diversity and greatest concentration of significant plant species (Ministry of Natural Resources, 2018). Cootes Paradise is a 250 Hectare drowned river-mouth marsh located at the westernmost point of Hamilton Harbour, Lake Ontario. Because of its size and location, it is an important migratory stop for waterfowl, as well as a major fish nursery for Lake Ontario (Lougheed, V. L, 2004). It is also home to a diverse array of plant and animal species, including rate and threatened species. Under the new Wetland Evaluation System, it is expected that 11 Hectares (4.4%) of Cootes Paradise will be vulnerable to loss of provincial protection. As mentioned above, these small wetlands may play an important role in providing landscape connectivity to species such as turtles and snakes and may also be important habitats for migratory waterfowl that depend on this wetland for feeding and resting.

2,850.47 Ha of small wetlands are predicted to lose their provincial protection across the four Ecodistricts, leaving them vulnerable to development or agricultural expansion. As habitat loss generally has negative effects on species distribution and abundance, this loss of protection will likely severely impact the biodiversity supported by wetlands. It is recommended that provincial protections be strengthened for wetlands of all sizes, protecting species communities by retaining the important habitat and ecosystem services that wetlands provide.

4.6 Policy recommendations

Based on the results of the Ontario wetland evaluation system re-evaluation model, several policy changes are recommended. First, it is recommended that the Ontario wetland evaluation system be altered to assume that all remaining wetlands are automatically considered provincially significant until evaluated as otherwise. Under this approach, the burden to evaluate the wetland would be on the person or company who aims to interfere with the wetland. Under this approach, those wishing to interfere with the wetland would need to obtain an official evaluation and demonstrate that the particular wetland does not meet the criteria of a provincially significant wetland.

Second, Wetland policies and programs need to be strengthened to address the main drivers of wetland loss, including agriculture and development. Wetland setback requirements can be used to restrict development and agricultural activities near wetlands in an attempt to minimize the impacts of runoff and pollution on wetland ecosystems. Recently in Ontario, the minimum buffer zone distance between development lands and wetlands was reduced from 120 metres to 30 metres. Policy decisions like this likely harm species at risk, as some move 50 metres or more between wetlands and terrestrial zones daily. It is recommended that provincial setback requirements should follow scientific evidence, and policy makers should consult conservation authorities to implement safe minimum setback requirements between development lands and wetlands.

It is also recommended that policy options such as wetland conservation incentive programs, conservation easements, and land trusts continue to be funded by the provincial government. Wetland conservation incentive programs may include tax exemptions for private landowners whose properties have wetlands, providing a financial incentive to conserve wetlands on private property. Conservation land trusts should continue to be funded by the provincial government to purchase wetland properties from willing landowners. By acquiring these properties, wetlands on private property can be conserved and protected from development and extraction.

Third, the provincial government should empower conservation authorities to effectively protect wetlands from all serious threats. As well as making drastic changes to the wetland evaluation system, The *More Homes Built Faster Act*, 2022, prevents municipalities from entering into agreements with Conservation Authorities to review planning applications on their behalf and removes conservation of lands and pollution as considerations in permitting decisions. This policy change shifts the role of reviewing and mandating changes to development applications to municipalities who may have little to no expertise in environmental hazard assessments. This could lead to development in flood-prone areas and allow development in areas where pollution may be a high risk to the surrounding environment. It is recommended that the provincial government empower Conservation Authorities to provide their environmental expertise and act as an advisory body for reviewing development applications.

Finally, if wetland loss is truly unavoidable, wetland offsetting regulations need to be developed to ensure that ecological function is successfully replaced. Wetland offsetting regulations should be developed through the creation, restoration, or preservation of wetlands elsewhere to compensate for wetland loss caused by development or land use change. Currently, no wetland offsetting policies are in place in Ontario. It is recommended that wetland offsetting regulations be developed to compensate for the predicted loss of wetlands due to the impacts of the *More Homes Built Faster Act,* 2022

5.0 Conclusion

Wetlands provide vital habitat for wildlife and ecological services for humans, including essential buffers against flooding, water filtration, and carbon storage. Without them, our environment loses further habitat for biodiversity and resilience to climate change. This study aimed to model the potential impacts of a change to the Ontario Wetland Evaluation System and to estimate the potential impacts on ecosystem services derived from wetlands in Ontario. Overall, the model indicates that Ontario will be vulnerable to a dramatic loss in wetland area due to the change in policy. Small provincially significant wetlands were calculated to make up 2.5% of all provincially significant wetland area in Southern Ontario, a seemingly small proportion. However, 2.5% of PSW area equates to 22,500 Hectares of wetland across Southern Ontario. The predicted loss of wetland area is likely to have impacts at the local, provincial, and even national level. Locally, municipalities may experience increased floods during periods of heavy precipitation and decreased water quality. Provincially, species at risk may continue to decline due to loss or fragmentation of their habitat. Nationally, carbon emissions may continue to rise due to peat extraction from important carbon reservoirs.

To better predict wetland loss as a result of provincially policy changes, a similar wetland loss model can be undertaken with the incorporation of previous wetland loss rates to provide a more accurate prediction of wetland loss across the province. This would provide a more region-specific model by incorporating historical wetland loss data. Additionally, this model does not consider the impacts of the changes to the special features category of the Wetland Evaluation System, as the dataset was incomplete and could not be applied across all of Southern Ontario. In the future, a wetland loss model could be applied to wetlands where the special features category data was available to model the full extent of changes to the Ontario Wetland Evaluation System.

To prevent further wetland loss, ecosystem services assessments should be used by decision-makers as a useful approach to conservation and urban planning. Cost-benefit analyses should be undertaken to understand the costs associated with maintaining/conserving wetlands versus the estimated ecosystem services they provide. This analysis can help to guide the prioritization of wetland conservation efforts throughout the province. Once considered an obstacle to development, wetlands should be viewed as natural assets to the landscapes they occupy.

6.0 References

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