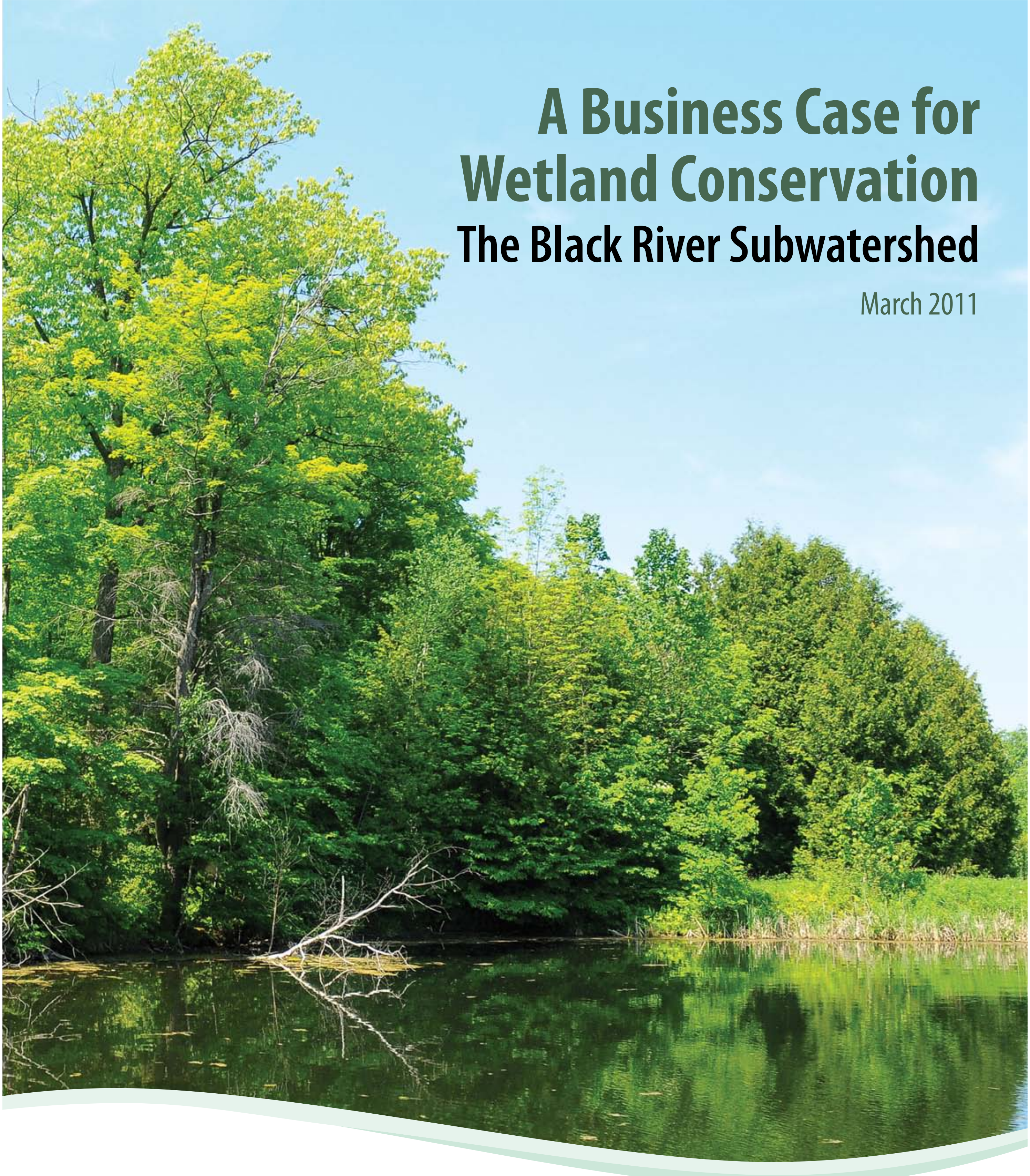

A Business Case for Wetland Conservation

The Black River Subwatershed

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Ducks Unlimited Canada
Conserving Canada's Wetlands

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Glossary of Terms

Agricultural Beneficial Management Practice (BMP): any agricultural management practice that addresses negative impacts and risk to the environment, ensures the long term health of land related resources used for agriculture, and does not negatively impact the long term economic viability of producers.

Benefit-Cost Analysis: a tool that compares the societal and/or governmental benefits and costs of a particular policy or management decision.

Benefit Transfer: a process by which the estimated benefit for one or more sites or policy proposals that is used to assign benefit or value to other comparable sites or policy proposals.

Business Case: a comprehensive assessment that provides rationale for a given project through the presentation of relevant material, including background information, expected benefits of the project, expected costs of the project, and the consideration of risk.

Contingent Valuation (CV): a survey-based economic valuation of non-market resources, such as wetlands, that relies on participants stating what they would be willing to pay for a particular resource.

Ecological Goods and Services (EGS): the goods and services provided by ecosystems and their functions, which are commonly considered to be environmental and economic benefits. This term is often used interchangeably with ecological goods and services, environmental services, or ecosystem services. This report uses the term ecological goods and services throughout.

Marginal Benefit: the change in total benefit that results from protecting or restoring one additional unit of a particular good or service.

Marginal Cost: the change in total cost that results from consuming, depleting, or damaging one additional unit of a particular good or service.

Natural Capital: the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future.

Revealed Preference Method: techniques that infer monetary valuations from the prices of related market-traded goods.

Social Return on Investment Method: a method for measuring extra financial value (i.e., environmental and social value not currently reflected in conventional financial accounts) relative to resources invested. It is an extension of the traditional cost-benefit method.

Social return on investment ratio (SROI): the social benefits of a proposed project divided by the costs. A social return ratio >1 indicates the benefits are greater than costs, while <1 infers the opposite.

Stated preference method: economic valuation techniques that determine the monetary value of non-market goods or services from the explicit response of individuals, often by means of a survey instrument.

Wetland Retention: represents the ongoing protection of both an existing wetland and its function through the restriction of development activities in and adjacent to the natural feature.

Wetland Restoration: the practice of restoring a historic wetland feature and/or its functions following its degradation, impairment or loss.

Willingness to Accept: a monetary measure of the minimum amount that an individual would accept to forgo a positive change in the quantity or quality of a good or service, or agree to for a negative change in the quantity or quality of a good or services.

Willingness to Pay (WTP): a monetary measure of the maximum amount that an individual would pay to obtain a positive change in the quantity or quality of a good or service, or to avoid a negative change in the quantity or quality of a good or service.

Executive Summary

Human conversion of natural ecosystems to other land uses occurs across Canada, but in areas of high population density the resulting environmental degradation is most evident. In the Lake Simcoe watershed of southern Ontario, agricultural conversion, urban expansion, and the construction of transportation corridors have significantly altered the historic natural landscape. While these developments have contributed to economic growth and prosperity for local residents, they have also led to the significant environmental degradation of Lake Simcoe. For instance, water quality decline from excessive phosphorous loading is a major concern for the local residents that rely on the lake for water and recreation.

The Lake Simcoe watershed has experienced a high degree of wetland loss and degradation. The Southern Ontario Wetland Conversion Analysis (DUC 2010) indicates that up to 72 per cent of the wetlands have been lost since settlement, and that wetland loss is continuing today despite a growing awareness within the scientific community and different levels of government of their benefits. Within the Black River subwatershed, wetland loss is known to exceed 45 per cent.

Ducks Unlimited Canada (DUC) believes, however, that wetland conservation has the potential to minimize the water quality degradation of Lake Simcoe. In order to test this belief, DUC and the University of Guelph have recently completed research into the ecological goods and services provided by riparian wetlands in the Black River subwatershed. This research measures the water quality implications of wetland loss and restoration under a number of different scenarios, relative to the baseline function of the currently existing wetlands. The Black River subwatershed has an annual flow of $67x10^6 m^3$ and currently discharges 1,126 tons of sediment, 51.2 tons of nitrogen and 5.3 tons of phosphorous into Lake Simcoe annually. Complete wetland loss in the subwatershed would result in a 4.5 per cent increase in annual flow, 13 per cent decrease in groundwater recharge capabilities, a 251 per cent increase in sediment load, a 260 per cent increase in nitrogen loading, and an 891 per cent increase in phosphorous loading.

Photo courtesy of LSRCA

The study then uses these water quality implications to estimate the economic value of these wetland services for society. The current costs of phosphorous and nitrogen filtration at the local Sutton Water Pollution Control Plant (WPCP) are used to assign a dollar value to the natural removal of these nutrient by wetlands. Other EGS studies are consulted to determine the economic value associated with biodiversity, carbon sequestration, and recreational use. A traditional benefit-cost analysis of relying on wetlands to provide phosphorous removal is then conducted. This uses a $27,664 up-front per hectare wetland restoration cost (DUC 2011) and a $386 annual per hectare opportunity cost (Brethour et al 2007). This is followed by a more complete assessment of the societal return on investment (SROI) of wetland conservation and restoration investments, based on the additional services that wetlands provide.

The benefit-cost analysis for phosphorous removal alone indicates that the annual benefit is approximately $292,661 ($315,632 for full restoration), while the cost to retain all the current wetlands is $2.9 million annually ($105.2 million for full restoration). This provides a benefit-cost ratio of approximately 0.1:1 for wetland retention, indicating that phosphorous reduction potential alone does not provide a desirable return on investment. However, lost benefit from wetland loss scenarios provides a strong argument for riparian wetland retention since phosphorous loading is expected to increase by 891 per cent should full wetland loss occur. When other wetland services are included in a comprehensive social return on investment framework, the economic benefits are 3.66 times greater than the costs for the retention of existing wetlands, 3.05 times greater than the cost when 5 per cent of the wetlands are restored, and 2.01 times greater than the costs when 25 per cent of the wetlands are restored. The full restoration of historic wetlands would not provide a net benefit because of the high restoration costs involved relative to diminishing returns in the benefits. These results should be considered conservative estimates, however, because the analysis omits services where an economic approximation specific to the Black River subwatershed was unavailable, such as groundwater recharge, sediment retention and flood control.

These findings provide a very strong business case for wetland retention and low levels of restoration. They demonstrate the following:

- The riparian wetlands in the Black River subwatershed are preventing phosphorous from entering Lake Simcoe, and will therefore assist in meeting the phosphorous reduction objectives of the Lake Simcoe Protection Plan.
- The phosphorous removal benefits currently provided by the Black River riparian wetlands would cost local governments $292,661 annually, based upon local filtration costs.
- *Further loss of wetlands* in the Black River subwatershed will significantly increase phosphorous loading to Lake Simcoe. Losing 2,088 hectares (approximately 25 per cent) of the existing riparian wetlands would negate the current annual phosphorous removal services of the Sutton WPCP. Losing 2,140 (another 52 hectares) of existing wetlands would negate the additional removal capacity of the proposed membrane ultra-filtration upgrades.
- *Restoration of wetlands* does not outweigh the economic opportunities of conversion to other land uses when phosphorous removal is the only consideration. However, when other environmental services are factored in, wetland retention and wetland restoration up to 25 per cent provides a positive societal return on investment within a 10 year period.
- *Retention of existing wetlands* provides the highest social return on investment. Further wetland loss would significantly affect the benefit of the financial investment in local water treatment facilities and agricultural BMP's in the Lake Simcoe watershed.

This business case is predicated on the fact that wetland conservation is an economically feasible option for preventing further environmental degradation in the Black River subwatershed, Lake Simcoe, and southern Ontario. Regulatory agencies and governments that are responsible for land use planning should include the economic benefits of riparian wetlands to society when considering changes to existing land uses.

1.0 Introduction

Ontario is endowed with natural ecosystems that provide many essential environmental and economic services to the provincial and local economies (Wilson 2008). Of these ecosystems, wetlands have been identified as the single most important source of natural capital (Troy and Bagstad 2009), providing a broad spectrum of ecological goods and services (EGS)[1]. These EGS include improved surface water quality, sustainable drinking water sources, mitigation of climate change and the impacts of droughts and floods, wildlife habitat, and biodiversity.

While the natural capital that wetland ecosystems provide is increasingly recognized by the public and policy makers[2] (Pattison et al 2011; Barbier et al 1997), it remains undervalued in the marketplace, and therefore misused. It has been estimated that 60 per cent of global ecosystems are being used at an unsustainable rate (MEA 2005), and wetland loss specifically is a growing ecological concern.

Photo courtesy of LSRCA

The Lake Simcoe watershed has been subject to high levels of agricultural conversion and urban development. Loss of wetlands has contributed to the severe eutrophication in Lake Simcoe. Nutrient loading, primarily due to phosphorous from agricultural run-off and urban wastewater, is impacting water quality and recreational activities. Concern over this degradation has led to various conservation initiatives, and most recently, a phosphorous reduction strategy (OMOE 2010). Ducks Unlimited Canada (DUC) believes that retention and restoration of wetlands in the subwatershed have the potential to assist in meeting these goals in an environmentally sustainable manner. Furthermore, DUC believes that wetland retention and restoration can be economically justified.

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1 Ecological goods and services is commonly used in the literature, but it can also be described as environmental and economic benefits.

2 Canada formalized a national wetland policy in 1991, and progressive policies have recently been enacted in Nova Scotia, New Brunswick, and Prince Edward Island. Alberta is currently moving its draft wetland policy forward (AWP 2009). Provincially significant wetlands are currently protected under the Ontario Provincial Policy Statement.

Quantifying the EGS of wetlands, and the economic feasibility of relying on wetlands to accomplish environmental objectives, such as Lake Simcoe phosphorous reduction, provides powerful driver for wetland conservation because most policy decisions are based on financial opportunities and constraints. Several recent publications from the Ontario Ministry of Environment and local conservation authorities have articulated the economic benefits derived from wetland ecosystems (Kennedy and Wilson 2009; Troy and Bagstad 2009; Wilson 2008). However, policy decisions concerning wetland retention and restoration expenditures need to be based on a clear understanding of the true comparison of benefits and costs provided by these wetlands, relative to the estimated. This comparison is essential for determining the net societal benefit or cost of conservation actions.

The purpose of this report is to present a business case for wetland conservation in the Black River subwatershed in order to encourage government and public support for wetland stewardship. Background information will be provided on the status of the wetland inventory and wetland conservation in the subwatershed, and their relevance to Lake Simcoe's water quality. The Black River EGS research will be used to quantify the economic benefits, and costs of wetland retention and restoration will be based upon local opportunity and restoration cost estimates. This will initially assess the economic feasibility of using wetlands to reduce phosphorous, followed by an expanded benefit-cost analysis that incorporates other benefits. The second analysis strives to examine wetlands in a more complete social return on investment (SROI) framework. Extrapolations will then be made to the entire southern Ontario region. The business case concludes with the recommendation that this information should be used to inform the public in order to drive public policy.

2.0 Background

Canada formally acknowledged the value of wetland ecosystems when it signed the Ramsar Convention on Wetlands in 1971, becoming the first national government to enact a wetland policy in 1991. Despite this action, wetlands in southern Ontario continue to be drained and degraded, with negative impacts on the natural environment and the quality of human life (Environment Canada 2009).

Since European settlement, approximately 20 million hectares of wetlands have been drained in Canada for agricultural purposes alone (Environment Canada 2009), with total loss from human development estimated to be 70 per cent. The Southern Ontario Wetland Conversion Analysis (DUC 2010) reports that prior to European settlement (circa1800) there were more than 2 million hectares of wetland in southern Ontario, covering 25 per cent of the landscape. By 2002, 72 per cent (1.4 million hectares) of wetland had been converted to other uses. Between 1982 and 2002, 3.5 per cent of the pre-settlement wetlands were lost, an average of 3,543 hectares per year.

In the Lake Simcoe watershed, wetlands cover 38,974 hectares (12%) of the total land base, and consist of swamp, marsh, shallow water with vegetation, fen, and shrub bogs (Wilson 2008). As in other parts of southern Ontario, this represents a significant decrease from the historical coverage. Historical wetland areas have been replaced primarily by urban development, agricultural expansion, rural cottage properties, urban brownfields, and transportation corridors (DUC 2010). The drainage policy, which has persisted since the early 1900's to provide food for expanding urban populations, accelerated the conversion to agricultural use (OMAFRA 1997) in order. The subwatershed's proximity to Toronto has enabled approximately a half million residents to commute or visit weekend cottages. Enhancements to transportation routes and service infrastructure to meet this demand have further altered the landscape.

This loss has occurred because natural wetland ecosystem values to society are not currently valued by the market system, and few financial incentives exist for landowners to maintain them. In the agriculture sector, profitability is dependent upon effective drainage (OMAFRA 1997)[3]. Wetlands can be costly for agricultural producers to maintain because of the increased fuel and time required to manoeuvre machinery around them during seeding and harvesting. In urban landscapes, wetland in-filling and drainage promote sprawl. In almost all situations, the value of the land is determined by its productive capacity to supply human needs.

An ineffective Provincial policy framework has also lead to continued wetland loss. The value of wetland ecosystems was recognized in a 1981 Provincial report that recommended the formation of a provincial wetland policy (OMNR 1981). It was not until 1992, however, that the Province of Ontario released a Wetland Policy Statement, which has been replaced with the Provincial Policy Statement (PPS), currently under revision. The PPS prohibits development within provincially significant

3 The Ontario Ministry of Agricultural, Food and Rural Affairs (OMAFRA) website currently states that "Profitable returns from farmland depend on effective drainage. A farmer may be convinced of the need for improved drainage but the complications that may arise when he considers undertaking such work often delay action" (OMAFRA 1997).

wetlands (Government of Ontario 2005). The PPS currently only protects wetlands identified and designated as provincially significant wetlands (PSW) and designation and enforcement are under-resourced. In southern Ontario this accounts for protection of approximately one third of all wetlands and a much smaller proportion of wetlands in the north.

Conservation Ontario and the member Conservation Authorities (CA) have an integral role in wetland conservation because they regulate development activities within and adjacent to wetlands (under the CA Act). While most CAs regulate all wetlands, others only regulate PSW that are identified in municipal land use plans (ECO 2010). Others have created their own wetland policies, and made significant effort to value and protect wetlands in their watershed (GRCA 2003).

In addition to regulatory protection, environmental organizations, such as DUC, Delta Waterfowl, the Nature Conservancy of Canada, David Suzuki Foundation and World Wildlife Fund[4] have partnered with landowners, government and academic institutions to stop wetland loss, raise public awareness, and in some cases, restore wetlands.

3.0 Phosphorous Loading in Lake Simcoe

3.1 Environmental Degradation

Lake Simcoe is the largest southern Ontario lake that is completely within the provincial boundaries. It has played an important role in Ontario's history by functioning as a transportation link for First Nation communities, fur traders, and the logging industry. During the last century, the human settlement within the watershed has grown rapidly. Lake Simcoe currently provides drinking water for eight municipalities (LSEMS 2008) and supports a successful tourism industry[5] that provides outdoor recreational opportunities for thousands of visitors and local residents every year. Agricultural land use accounts for 47 per cent of the subwatershed, and generates millions of dollars in production each year (OMOE 2010).

Photo courtesy of LSRCA

A major environmental concern is the degraded water quality of the Lake. In particular, phosphorus loading from urban and agricultural sources has impaired the natural ecosystem and impacted the recreational attractiveness (OMNR 2010). Widespread concern over this degradation culminated in the *Lake Simcoe Protection Act* (OMOE 2010) and a subsequent Protection Plan that signalled the provincial government's intent to improve environmental conditions. The Lake Simcoe Protection Plan addresses:

- stresses from human activities and excessive levels of phosphorus;
- the loss or disruption of sensitive natural areas the habitats of fish and other wildlife;
- and the water quality and quantity impacts that interfere with natural ecosystems, and consequently, the amount and suitability of water for human consumption.

The Ontario Ministry of Environment, Ontario Ministry of Natural Resources, the Lake Simcoe Region Conservation Authority, and local stakeholders have recently collaborated on the Phosphorous Reduction Strategy (OMOE 2010). The primary objective of the strategy is to identify practical and effective actions that reduce the amount of phosphorous entering Lake Simcoe. This is a difficult objective, considering the existing human development and anticipated growth in the watershed.

3.2 Black River Subwatershed

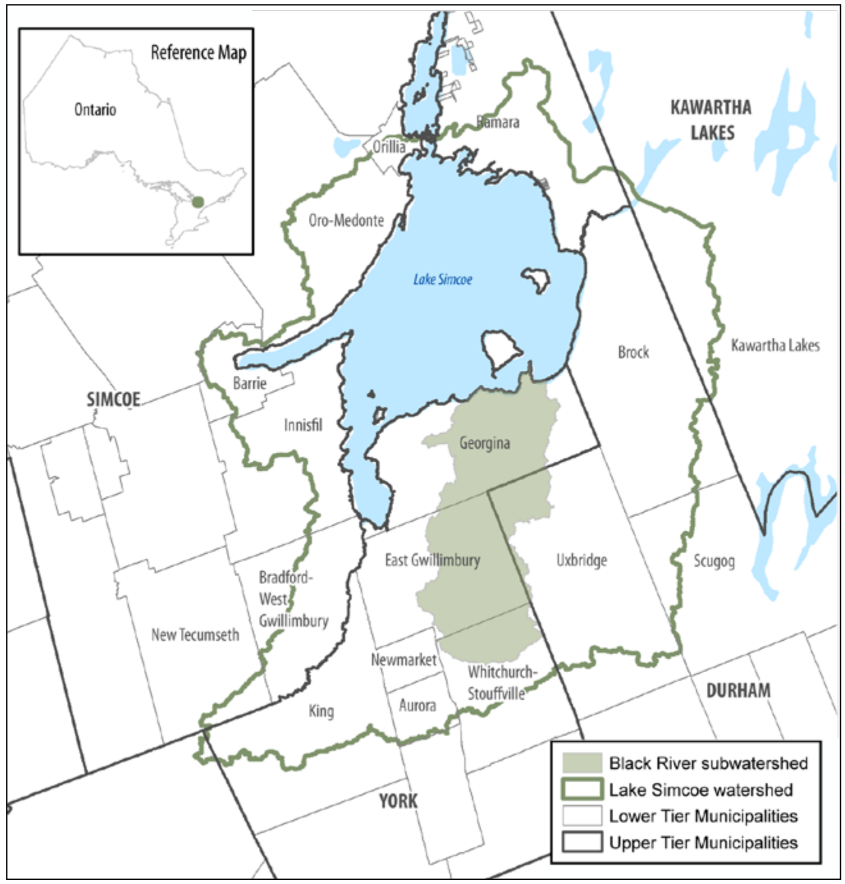
DUC believes that wetlands can help the stakeholders achieve this objective. To determine whether or not this is the case, DUC

4 Among others

5 Approximately $200 million annually to the local economy (OMOE 2010).

partnered with the Guelph Watershed Evaluation Group (WEG) to conduct research in Black River, a subwatershed within the Lake Simcoe Watershed. The subwatershed was chosen by the project stakeholder group based on several criteria, which included the similarity of the subwatershed to the remainder of southern Ontario, the condition of the subwatershed, and the need to assess options for phosphorous reduction in the Lake Simcoe watershed[6]. As such, scientific evidence that establishes the environmental and economic values of wetlands for this subwatershed can be extrapolated to other subwatersheds in southern Ontario.

Figure 1 - The Lake Simcoe watershed and Black River subwatershed of southern Ontario



The Black River subwatershed is located southeast of Lake Simcoe, within the Regional Municipalities of York and Durham (Figure 1). As with many of the subwatersheds that are south of Lake Simcoe, the headwaters of the Black River originate on the Oak Ridges Moraine. In 2008, 7,721 hectares of the Black River subwatershed were wetland[7], which is a significant decrease from the approximately 11,237 hectares that existed in the 1800s. This represents a loss of 3,515 hectares, or approximately 33 hectares of wetland annually (Yang et al 2011).

4.0 Benefits of Wetlands

The contributions of wetlands to ecosystem health are commonly cited (Environment Canada 1991; MEA 2005). These benefits include biodiversity enhancement, flood water control, erosion control, groundwater recharge, surface water quality improvements (reduction of nitrogen and phosphorous in particular), and carbon sequestration (Environment Canada 2009). While many wetlands provide these benefits, the degree of benefit varies across regions and wetland classification types. For instance, coastal wetlands function differently than wetlands in the boreal forest or prairie pothole regions. Precise estimates of the ecological goods and services of specific wetland functions are often not available because of the heterogeneity between wetlands, and the financial constraints of conducting research. As a result, policy-makers must often rely on techniques like benefit transfers.

New research from the Black River subwatershed addresses this limitation. Yang et al (2011) have quantified the phosphorous, nitrogen, sediment load, water flow, and groundwater recharge capacity under several wetland restoration and loss scenarios, relative to the existing inventory of riparian wetlands (Table 1).

6 As determined by the project stakeholder group with representatives from Ontario Ministry of Agriculture, Food and Rural Affairs, Agriculture and Agri-Food Canada, Ontario Ministry of Natural Resources, Conservation Ontario, Credit Valley Conservation, Lake Simcoe Region Conservation Authority, Ontario Federation of Agriculture.

7 These consist of swamp (92.6%;%), marsh (7.3%;%), and Bog bog and fen (0.1%%) (Yang et al 2011).

Table 1:
Wetland Restoration and Loss Scenarios

Scenarios	Description
Rest100	Restoration of 100% of the historic wetland area with the Black River subwatershed
Rest25	Restoration of 25% of the historic wetland area with the Black River subwatershed
Rest5	Restoration of 5% of the historic wetland area with the Black River subwatershed
Existing	Retention of the existing wetland area within the Black River subwatershed
Loss5	5% Loss of existing wetland area within the Black River subwatershed
Loss25	25% Loss of existing wetland area within the Black River subwatershed
Loss100	100% Loss of existing wetland area within the Black River subwatershed

This specific information enables much greater precision when incorporating the economic importance of wetlands into land use decisions. The following sections quantify the importance of each service provision in detail.

4.1 Phosphorous Removal

Wetlands have high rates of primary productivity and therefore are effective at breaking down and removing nutrients such as phosphorous from water. Under current conditions, which include 7,590 hectares of riparian wetland, the Black River discharges approximately 5,300 kg of phosphorous into Lake Simcoe annually. Relative to the existent level of riparian wetlands, this would decrease by 37 per cent (1,960 kg/yr) if all wetlands were restored, and would increase by 891 per cent (52,540 kg/yr) if all the existing wetlands were drained. As Table 2 indicates, the effects on phosphorous removal through restoration and loss are not linear[8]. Wetland restoration exhibits decreasing returns because the volume of total phosphorous removed increases at a diminishing rate. Wetland loss, however, demonstrates the opposite trend.

Phosphorous retention can also be valued economically. When the change in hectares under each scenario is multiplied by the phosphorous removal costs, it provides the change in annual phosphorous removal benefit relative to the existent level of wetlands (Table 2)[9]. Wetland restoration scenarios result in an increase of annual phosphorous removal benefit that ranges from $4,336 (5 per cent) to $22,971 (100 per cent). Wetland loss scenarios, representing the lost annual phosphorous removal benefit from the current situation, range from $4,102 (5 per cent) to $553,653. The implications of these results will be discussed in greater detail in Section 6.1.1.

Photo courtesy of LSRCA

8 The per hectare removal rate was calculated by dividing the change in TP by the change in hectares under each scenario.

9 The change in benefit column was calculated by multiplying the change in TP in each scenario by the $11.72 phosphorous removal rate from the Sutton WPCP (WEAO 2010).

Table 2.
A summary of the annual phosphorous removal capacity of Black River riparian wetlands and their associated economic benefit under several loss and restoration scenarios (Yang et al 2011).

Scenario	Wetland area		TP load	Change of TP load		Per Ha Removal (ΔTP/ΔHa)	Change in Benefit* (ΔHa x ΔTP x $)
	ha	Change	kg/y	kg/y	%	kg/y	$/y
Rest100	11,237	3,647	3,340	(1,960)	(37.0)	(0.54)	22,971
Rest25	8,502	912	4,270	(1,030)	(19.4)	(1.13)	12,072
Rest5	7,773	183	4,930	(370)	(7.0)	(2.02)	4,336
Existing	7,590	0	5,300	0	0.0	0	0
Loss5	7,211	379	5,650	350	6.6	0.92	(4,102)
Loss25	5,693	1,897	7,550	2,250	42.5	1.19	(26,370)
Loss100	0	7,590	52,540	47,240	890.9	6.22	(553,653)
** based upon a $11.72/kg average cost to remove phosphorous from the Sutton WPCP (WEAO 2010).*							

This information emphasizes the importance of preventing further wetland loss because the continual loss of riparian wetlands will result in an exponential increase in phosphorous reaching Lake Simcoe.

4.2 Nitrogen Removal

As in the case of phosphorous, the biological processes within wetlands are also effective at removing nitrogen from water. With the current coverage of riparian wetlands, the Black River discharges approximately 51,000 kilograms of nitrogen into Lake Simcoe annually. This would decrease by 28 per cent if all historic wetlands were restored, and would increase by 260 per cent if all existing wetlands were lost. Based on a filtration cost of $5.75 per kilogram (Olewiler 2004)[10], the annual change in economic benefit relative to the existing level of wetlands would increase by $83,145 if all historic wetlands were restored, and decrease by $766,130 if all existing wetlands were lost (Table 3)[11]. As with phosphorous reduction, wetland loss increases the quantity of nitrogen entering Lake Simcoe at an accelerating rate.

Table 3.
A summary of the annual nitrogen removal capacity of Black River riparian wetlands under several loss and restoration scenarios relative to the existent level of wetlands (Yang et al 2011).

Scenario	Wetland area		TN load	Change of TN load		Per Ha Removal (ΔTN/ΔHa)	Change in Benefit* (ΔHa x ΔTN x $)
	ha	ha Change	kg/y	kg/y	%	kg/y	$/y
Rest100	11,237	3,647	36,700	(14,460)	(28.26)	(3.96)	83,145
Rest25	8,502	912	44,640	(6,510)	(12.73)	(7.14)	37,433
Rest5	7,773	183	49,320	(1,840)	(3.59)	(10.05)	10,580
Existing	7,590	0	51,150	0	0	0	0
Loss5	7,211	379	53,220	2,070	4.04	5.46	(11,903)
Loss25	5,693	1,897	62,020	10,870	21.24	5.73	(62,503)
Loss100	0	7,590	184,000	133,240	260.47	17.55	(766,130)
** based upon a $5.75/kg average cost to remove nitrogen from wastewater facilities (Olewiler 2004)*							

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10 Nitrogen removal costs range from $3 to $8.50 per kilogram (Olewiler 2004); an average cost of $5.75 was used for calculations in Table 3.

11 The per hectare removal rate was calculated by dividing the change in TN by the change in hectares under each scenario. The change in benefit column was calculated by multiplying the change in TN in each scenario by a $5.75 phosphorous removal costs (Olewiler 2004).

4.3 Flood Control

Wetlands help to control flooding by regulating the flow of water during spring snow melt and periods of high rainfall. With the current inventory of riparian wetlands, the Black River has an annual discharge of approximately 65 $10^6 m^3/y$ into Lake Simcoe. This would decrease by 3.4 per cent if all historic wetlands were restored, and would increases by 6.7 per cent if all existing wetlands were lost. Although the economic benefits of flood water control have been estimated at around $1,200 per hectare (Wilson 2008; Olewiler 2004) these estimates are not directly transferable to flooding conditions in the Black River. Consequently, the flood control benefits are not included in the final cost-benefit analysis, although these benefits clearly exist.

Table 4.
A summary of the annual flood control capacity of Black River riparian wetlands under several loss and restoration scenarios (Yang et al 2011).

Scenario	Wetland area		Flow volume	Change of flow volume		Per Ha Retention
	ha	Change	$10^6 m^3/y$	$10^6 m^3/y$	%	m^3/y
Rest100	11,237	3,647	64.78	(2.28)	(3.41)	(626)
Rest25	8,502	912	66.44	(0.62)	(0.93)	(683)
Rest5	7,773	183	66.93	(0.13)	(0.19)	(714)
Existing	7,590	0	67.06	0	0	0
Loss5	7,211	379	67.21	0.16	0.23	412
Loss25	5,693	1,897	67.87	0.81	1.21	428
Loss100	0	7,590	71.53	4.47	6.67	589

4.4 Sediment Load

Wetlands capture sediment before it is swept downstream, helping to retain topsoil on agricultural fields, and to decrease turbidity and sediment accumulation downstream. With the current inventory of riparian wetlands, the Black River discharges approximately 1,100 tons of sediment into Lake Simcoe annually. This would decrease by 35 per cent if all historic wetlands were restored, and would increase by 251 per cent if all existing wetlands were lost. A non-linear relationship is again evident. The quantity of sediment that each wetland hectare annually retains, relative to the existing level, ranges from a decrease of 107 kg/yr when all historic wetlands are restored, to an increase of 373 kg/yr when all the existent wetlands are lost (Table 5). Society's willingness to pay for erosion prevention in southern Ontario has not been determined, and is consequently not reflected in Table 5.

Table 5.
A summary of the annual sediment retention capacity of Black River riparian wetlands under several loss and restoration scenarios (Yang et al 2011).

Scenario	Wetland area		Sediment load	Change of sediment load		Per Ha Retention
	ha	Change	t/y	t/y	%	kg/y
Rest100	11,237	3,647	737	(388.8)	(34.52)	(107)
Rest25	8,502	912	952	(174.1)	(15.46)	(191)
Rest5	7,773	183	1,066	(59.9)	(5.32)	(327)
Existing	7,590	0	1,126	0	0	0
Loss5	7,211	379	1,167	40.8	3.62	108
Loss25	5,693	1,897	1,400	274.3	24.36	145
Loss100	0	7,590	3,957	2831	251	373

4.5 Groundwater Recharge

The current coverage of riparian wetlands recharges approximately 101.26 mm of groundwater to the existing aquifer annually. This would increase by 4 per cent if all historic wetlands were restored, and would decrease by 13.5 per cent if all existing wetlands were lost

(Table 6). As with previously discussed wetland services, the importance of maintaining groundwater levels for drinking water purposes is understood, but the economic value has not been quantified and cannot be provided in Table 6.

Table 6.
A summary of the annual groundwater recharge capacity of Black River riparian wetlands under several loss and restoration (Yang et al 2011).

Scenario	Wetland area		Recharge	Change of recharge	
	ha	Change	mm	mm	%
Rest100	11,237	3,647	105.19	3.93	3.88
Rest25	8,502	912	102.25	0.99	0.98
Rest5	7,773	183	101.46	0.2	0.2
Existing	7,590	0	101.26	0	0
Loss5	7,211	379	100.59	(0.67)	(0.66)
Loss25	5,693	1,897	97.90	(3.36)	(1.32)
Loss100	0	7,590	87.75	(13.51)	(13.34)

4.6 Other Services

Although the Black River research emphasizes the water quality benefits, other services should be acknowledged when identifying the contribution of wetlands to society. These include biodiversity, carbon sequestration and societal and economic benefits through recreation and tourism. There are no economic valuations for these benefits in the Black River subwatershed, although a number of approximations can be used. Assuming that the outdoor tourism industry on Lake Simcoe depends on the health of an intact natural ecosystem in the subwatershed, the $200 million annual contribution of the industry to the economy can be determined per hectare of remaining natural areas (Wilson 2008). This equates to a value of $1,231 per hectare [12]. Using a benefit transfer approach, Troy and Bagstad (2009) estimate that wetland biodiversity in southern Ontario is worth $75 per hectare. Based on a global average of wetland greenhouse gas emissions and carbon payments in other locations, Wilson (2008) estimates the value of carbon sequestration is worth $13 per hectare annually. Table 7 provides the estimates from these studies for the existing wetland inventory, and for different scenarios of wetland loss and restoration in the Black River subwatershed[13].

Table 7.
A summary of the additional services provided by Black River riparian wetlands based upon comparable southern Ontario per hectare benefit estimates of wetland service provision.

Scenario	Wetland area		Biodiversity	Carbon Storage	Tourism and Recreation	Total
	ha	Change	$/y	$/y	$/y	$/y
Rest100	11,237	3,647	842,775	146,081	13,832,747	14,821,603
Rest25	8,502	912	637,650	110,526	10,465,962	11,214,138
Rest5	7,773	183	582,975	101,049	9,568,563	10,252,587
Existing	7,590	0	569,250	98,670	9,343,290	10,011,210
Loss5	7,211	379	540,825	93,743	8,876,741	9,511,309
Loss25	5,693	1,897	426,975	74,009	7,008,083	7,509,067
Loss100	0	7,590	-	-	-	-

12 This approach was used by Wilson (2008) in the Lake Simcoe basin and is more conservative than the $3,551 per hectare estimate provided by Troy and Bagstad (2009) for the southern Ontario region.

13 The lack of specific data for these services does not allow a presentation of scenario specific benefits relative to the existent level of wetlands, as found in the previous sections. Therefore a linear per hectare benefit is assumed.

5.0 Costs of Wetlands

While specific costs of wetland restoration and retention can be difficult to determine, for the purposes of this report, the costs associated with retention and restoration activities are divided into two general categories [14]: fixed costs for restoring wetlands and opportunity costs for denying an alternative land use.

The fixed costs are the specific financial expenditures for physically restoring a drained or degraded wetland. DUC (2011) estimates that the per hectare cost of wetland restoration in the Lake Simcoe watershed, including direct construction, future management, and administration, is $27,664 [15]. A more detailed breakdown of restoration costs is provided in Appendix C.

The opportunity costs are financial returns that would accrue from the most profitable alternative. For example, keeping wetlands in their natural state forgoes a financial opportunity from agricultural production or urban development. An accurate understanding of opportunity costs is important for long term wetland retention because most wetlands are found on private land. When agricultural use is the main development pressure, the opportunity cost is related to commodity prices and expected crop yields. The opportunity costs of forgoing urban development are related to returns from housing, retail, or industrial prices.

Table 8 provides cost estimates for wetland restoration and retention in the Black River subwatershed that correspond to the restoration and loss scenarios provided by Yang et al (2011). Restoration costs are an up-front expenditure derived from DUC data in southern Ontario, while opportunity costs are based upon a Brethour et al (2007) estimate for agricultural land in southern Ontario, which is estimated to be $385.82 per hectare annually. This estimate is based solely on prime agricultural lands, does not include marginal agricultural lands, and represents agricultural land rental rates. If the estimate included urban opportunity costs this estimate would be much higher.

Table 8.
A summary of annual cost estimates of wetland retention and restoration scenarios in the Black River subwatershed under several loss and restoration scenarios.

Scenario	Wetland area		Total Restoration Cost	Total Opportunity Cost	Total Cost
	ha	Change	$	$	$
Rest100	11,237	3,647	100,890,608	4,335,459	105,226,067
Rest25	8,502	912	25,229,568	3,280,242	28,509,810
Rest5	7,773	183	5,062,512	2,998,979	8,061,491
Existing	7,590	0	-	2,928,374	2,928,374
Loss5	7,211	379	-	2,782,148	2,782,148
Loss25	5,693	1,897	-	2,196,473	2,196,473
Loss100	0	7,590	-	-	-

6.0 Cost-Benefit Analysis

This section analyzes the economic feasibility of wetland conservation using two methods: a benefit-cost comparison that is focussed specifically on phosphorous removal in the subwatershed; and a social return on investment (SROI) analysis that incorporates many of the additional EGS values provided by wetlands. The results from the Black River subwatershed study are used whenever possible, but are also supplemented by other wetland EGS studies in southern Ontario in the SROI. The final estimates are conservative, because the wetland values that currently lack proxy data [16], such as sediment control, flood water retention and groundwater recharge are not reflected in either analysis.

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14 Nuisance costs are a third category described in the literature (Packman 2010; Cortus 2005) but are not considered in this analysis due to limited availability of southern Ontario estimates.

15 It should be noted that this figure provides the complete spectrum of costs associated with wetland restoration, including future management and fundraising, and is therefore significantly higher than other wetland restoration estimates in the region (Wilson 2008; IJC Study Board 2006).

16 Primary wetland valuation often require the use of survey instruments, where respondents are asked to state what the environmental benefits provided by wetlands are worth to them.

The analyses rely on a net present value calculation and a benefit cost ratio that are calculated for three time periods, and for each potential land use scenario. The time periods are: the initial year, 10 years and 30 years. The annual benefits and costs over the retention time periods were discounted and summed for the present value using the following formula:

$$PV = \sum_{t=1}^{T} \frac{TC_i^t}{(1+r)^t}$$

where *TC* is the total cost (or benefit), *r* is the discount rate and t is the time period summed over the total time period *T*. The fixed costs for wetland restoration were incorporated as an up-front cost in the initial year. This calculation is used for both the benefits and costs, which are subtracted from each other to determine the net present value (NPV) in 2011 dollars using a 3 per cent discount rate [17]. The subsequent benefit cost ratio is calculated by dividing the present value benefits by the present value costs; a ratio >1 indicates that benefits exceed the costs, and vice versa.

6.1 Phosphorous Reduction Potential

Wetlands are commonly considered a cost effective method for treating wastewater because they require minimal operational and maintenance costs to achieve equivalent secondary treatment effluent results (de Bashan and Bashan 2004; Gray 2006; Bryhn 2009). Nutrients, such as phosphorous and nitrogen, are readily removed by the organic material within wetlands, which avoids costly chemical or mechanical filtration techniques.

The Lake Simcoe Phosphorous Reduction Strategy has a target discharge volume from all sources into the Lake of 44 tons/year (OMOE 2010). To determine the economic feasibility of using wetlands to assist in meeting this goal, the cost of phosphorous removal through treatment facilities can be compared with the nutrient removal capacity of Black River riparian wetlands.

6.1.1 Wetland Loss Scenarios

In 2008, 7,590 hectares of wetlands remained in the Black River subwatershed, however, approximately 33 hectares [18] of wetlands are lost annually because there are no economic incentives for landowners to retain these areas. The lost phosphorous removal benefit relative to the existing level of riparian wetland is calculated by multiplying the change in total phosphorous removal capacity (from Table 2) by the equivalent removal costs at the Sutton WPCP (Table 9). This provides an economic estimate of the lost benefit relative to the existing scenario: a 5 per cent loss of existing wetlands would result in an equivalent monetary loss of $4,102; a 25 per cent loss of existing wetlands equates to a $26,370 loss; and a 100 per cent of existing wetlands equates to a $553,653 loss.

Photo courtesy of LSRCA

The loss scenarios illustrate the importance of wetland retention. As the hectares of riparian wetlands decrease, the remaining wetlands filter a higher amount of phosphorous, making them more valuable per hectare. While this loss of benefit is not captured by the current market system, these costs will be borne indirectly by the general public in the form of increased costs associated with other phosphorous reduction measures implemented under the Lake Simcoe Protection Plan and impact on tourism revenues from increased environmental degradation.

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17 Stern (2005) suggests that traditional measures of discount rates are often too high when applied to the environment, and that environmental services value may in fact increase into the future as they become more scarce. Therefore lower discount rates should be considered.

18 Average historical loss rate in Black River.

Table 9.
The annual lost economic benefit from wetland phosphorous removal services relative to the benefit currently provided by existent wetlands.

Scenario	Lost Benefit $/year
Existing	0
Loss5	(4,102)
Loss25	(26,370)
Loss100	(553,653)

6.1.2 Wetland Loss and the Sutton WPCP

The Sutton Water Pollution Control Plant (WPCP) receives municipal wastewater and treats it so that the quality of the effluent released into Lake Simcoe via the Black River meets the water quality guidelines set by the provincial government. Phosphorous removal data from the Sutton WPCP provides context and emphasizes the importance of preventing further loss of riparian wetlands in two ways. First, the annual phosphorous removal rate from the WPCP was 2,480 kg in 2008 (WEAO 2010). A loss of 2,088 hectares (approximately 25 per cent) in riparian wetlands would increase the load of phosphorous to Lake Simcoe by 2,480 kg per year and effectively negate any phosphorous removal benefits from the Sutton WPCP.

Second, a general comparison can be made to the proposed ultra-membrane filtration upgrades, described in WEAO (2010), that to date remain conceptual. Such upgrades would include capital costs of $3.8 million and operating costs of $190,000 annually for an additional 62 kg per year removal rate and total phosphorous removal capacity of 2,542 kg/year. Over a 25-year life cycle this would increase the cost of phosphorous removal by 350 times or $4,189 per kg phosphorous removed. Based on a conservative 1.2 kg/ha/year removal rate, losing 2,140 hectares (additional 52 hectares) of wetland from the existing inventory would lead to an 2,542 kg/yr increase in phosphorous loading to Lake Simcoe, and nullify the water treatment upgrade.

This comparison highlights the ineffectiveness of investing in water filtration upgrades at the Sutton WPCP while continuing to lose wetlands in the subwatershed. Approximately 52 hectares of wetlands will provide the same service as annual increase in phosphorous removal capacity from the upgrade.

6.1.3 Wetland Retention and Restoration Scenarios

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The economic feasibility of restoring wetlands to alleviate phosphorous loading to Lake Simcoe is provided in Table 10. The table provides comparisons of the economic benefit and cost of wetland retention and three restoration scenarios. The phosphorous filtration benefit from the existing wetlands was determined by multiplying the total number of wetland hectares by the annual per hectare phosphorous removal rate (of 3.29 kg/ha/yr [19]) and the cost of mechanical phosphorous filtration ($11.72 per kg at the Sutton WPCP). The phosphorous removal benefit of each restoration scenario is a summation of the benefit of the existing wetlands and the increase in benefit from each scenario (as described in Table 2). Costs were determined by multiplying opportunity cost ($385/ha) by the total number of wetland hectares retained or restored, and when wetlands were restored, the additional up-front restoration cost ($27,664/ha). Total benefits and total costs were subtracted to determine the net present value.

The results indicate that existing wetlands in the Black River subwatershed will provide a present value of approximately $2.5 million over the next 10 years, and $5.7 million over the next 30 years in phosphorous filtration benefit. This would increases to $2.7 million (10 years) and $6.2 million (30 years) if all historic wetlands were restored. The cost to retain the current level of wetlands is $22.5 million over 10 years, and would increase to $283.1 million (30 years) if all historic wetlands were restored. The net present value (benefit – cost) of retention of existing wetlands and restoration is negative in every case.

19 Specifics regarding the determination of this number is found in Appendix A.

Table 10.
Comparison of phosphorus removal benefits and costs for the retention of existing wetlands and 5%, 25% and 100% riparian wetland restoration scenarios for an initial, 10 year and 30 year time horizon.

Scenario	Time Frame	Present Value of Benefits (P Removal)	Present Value of Costs (Retention and Restoration)	Net Present Value	Benefit Cost Ratio
Rest100	Initial Year	315,632	105,226,067	(104,910,435)	0.0030
	10 years	2,692,409	138,982,426	(237,180,625)	0.011
	30 years	6,186,536	188,416,832	(283,120,904)	0.021
Rest25	Initial Year	304,733	28,509,810	(28,205,077)	0.011
	10 years	2,599,433	54,050,128	(76,680,263)	0.033
	30 years	5,972,899	91,452,577	(110,709,246)	0.051
Rest5	Initial Year	296,998	8,061,491	(7,764,493)	0.039
	10 years	2,533,451	30,731,759	(33,260,820)	0.071
	30 years	5,821,286	63,931,170	(63,172,396)	0.084
Existing	Initial Year	292,661	2,928,374	(2,635,713)	0.100
	10 years	2,496,460	24,979,622	(22,483,162)	0.100
	30 years	5,736,290	57,397,419	(51,661,128)	0.100

6.1.4 Conclusions

This analysis indicates wetland retention and restoration costs will not be covered by phosphorous filtration benefits alone – water treatment facilities are more cost effective. However, should wetland loss continue on its current trajectory, the phosphorous removal capacity of the remaining riparian wetlands will result in a non-linear impact on phosphorous removal. The lost benefits of these remnant wetlands will become significantly greater as more wetlands are lost. For instance, losing the next 25 per cent of the existing wetlands will negate the current phosphorous removal capacity of the Sutton WPCP, and the loss of an additional 52 hectares will negate expensive upgrades to the Sutton WPCP. This alone should be a major economic incentive for retaining the existent wetlands. Riparian wetlands provide a number of additional services that must be factored into this comparison, and these will be focus of the next section.

6.2 Partial Social Return on Investment (SROI)

The SROI builds on the principles of the traditional benefit cost analysis, but is specifically intended to incorporate social and environmental values into an economic analysis[20]. As such, it is a useful framework for wetland retention and restoration scenarios. What follows is a partial, and therefore conservative, estimate of the social return on investment provided by riparian wetlands in the Black River subwatershed. The costs provided in the analysis are again based exclusively on agricultural opportunity costs for wetland retention, and fixed costs for wetland restoration[21]. Wetland benefits provided in the analysis are taken from the Black River study and several southern Ontario wetland EGS estimates. The benefits for the SROI include phosphorous and nitrogen removal, recreation and tourism, biodiversity and carbon sequestration values.

20 SROI has been used effectively by various organizations, including the city of Calgary, the New Economics Foundation in the United Kingdom, the Rotman School of Management at the University of Toronto, Carleton University, etc.

21 The opportunity cost of wetland loss to urban development were not included in the analysis.

6.2.1 Loss Scenarios

Continual loss of wetlands will result in lost benefit from phosphorous and nitrogen removal[22], biodiversity ($75 per ha), carbon sequestration ($13 per ha), and outdoor recreational values ($1,231 per hectare) annually. There were 7,590 hectares of wetlands remaining in the Black River subwatershed in 2008; a 5 per cent loss of existing wetlands would have an equivalent economic loss of $0.51 million; 25 per cent loss of existing wetlands equates to a $2.6 million loss; and 100 per cent loss of existing wetlands equates to a $11.3 million loss (Table 11)[23].

Table 11.
The annual lost economic benefit from wetland services relative to the benefit currently provided by existent wetlands.

Scenario	Lost Benefit $/yr
Existing	0
Loss5	515,906
Loss25	2,591,016
Loss100	11,330,993

6.2.2 Retention and Restoration Scenarios

The economic feasibility of restoring wetlands to provide additional societal benefit is presented in Table 12. The benefits were determined by multiplying the total number of wetland hectares in each scenario by the per hectare benefits [24]. Costs were determined by multiplying opportunity cost ($385/ha) by the total number of wetland hectares retained and when wetlands were restored, the additional up-front restoration cost ($27,664/ha). Total benefits and total costs were subtracted to determine the net present value.

Retention of existing wetlands in the Black River subwatershed provides a net benefit of $7.8 million within the first year; $66.5 million over 10 years; and $152.8 million over 30 years (Table 12). Retention, therefore, provides a social return on investment of 3.66, indicating that for every $1 spent on wetland retention society receives $3.66 in benefit.

The wetland restoration scenarios assume that the existing wetland base will be maintained, and that restoration costs will occur in the first year. The restoration of 5 per cent, or 183 hectares of wetlands, generates a net benefit of approximately $2.9 million in the first year, $57.2 million over 10 years, and $144.6 million over 30 years. The SROI is initially at 1.36, but increases to 3.05 over 30 years because restoration costs are incurred in the first year. The restoration of 25 per cent (912 ha) of historic wetland generates a net loss of approximately $16.5 million over the first year, changing to a net benefit of $22.9 million over 10 years, and $118.1 million over 30 years (Table 12). The up-front restoration costs provide a negative NPV in the first year, but this changes over time as the benefit outweighs the initial restoration investment. The longer time frames yield a SROI ratio of 1.29 and 2.01 for the 10 year and 30 year timeframes respectively.

Complete restoration of 100% of historical wetlands is unlikely to occur but provides an interesting perspective. The restoration of all historic wetlands (3,647 hectares) generates a net loss of approximately $89.6 million in the first year due to initial restoration costs; $106.5 million over 10 years, and a net benefit of $17 million over 30 years (Table 12). The benefits derived from this scenario do not justify the cost across time horizons, and while the SROI ratio does increase, it remains essentially at or below 1.

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22 Lost economic benefit for each scenario is dependent upon scenario specific removal rates (see Tables 2 and 3).

23 The lost benefit under each scenario is a summation of the decrease in services relative to the existent levels for phosphorous, nitrogen, biodiversity, carbon sequestration and recreation.

24 The P and N benefit of the existing level of wetlands was based upon a 3.29 kg/ha/yr phosphorous removal capacity and 9.64 kg/ha/yr nitrogen removal capacity (Appendix A), and their respective mechanical filtration costs ($11.72 kg/P and $5.75 kg/N). The additional P and N removal for the restoration scenarios is based on Tables 2 and 3. The per hectare benefits from biodiversity, carbon and recreation for each scenario is provided in Section 4.6.

Table 12.
Comparison of benefits and costs for full retention and 5%, 25% and 100% riparian wetland restoration scenarios, for an initial, ten year and 30 year time horizon.

Scenario	Options	Total Benefits	Total Costs	Net Present Value	SROI
Rest100	Initial Year	15,641,094	105,226,067	(89,584,973)	0.15
	10 years	133,421,706	138,982,426	(106,451,328)	0.56
	30 years	306,572,349	188,416,832	17,264,909	1.06
Rest25	Initial Year	11,977,017	28,509,810	(16,532,793)	0.42
	10 years	102,166,385	54,050,128	22,886,689	1.29
	30 years	234,754,821	91,452,577	118,072,676	2.01
Rest5	Initial Year	10,980,878	8,061,491	2,919,388	1.36
	10 years	93,669,120	31,411,867	57,194,741	2.57
	30 years	215,230,063	65,607,261	144,560,290	3.05
Existing	Initial Year	10,724,585	2,928,374	7,796,211	3.66
	10 years	91,482,885	24,979,622	66,503,263	3.66
	30 years	210,206,599	57,397,419	152,809,180	3.66

6.2.3 Conclusion

When additional wetland services are added to the phosphorous removal service, riparian wetland retention and restoration are economically feasible. This analysis confirms the results of the previous section, which found that the greatest social return on investment comes from retaining and preventing the further loss of Black River wetlands. This is because the decrease in benefits increases significantly as the existing inventory is lost. While the restoration of up to 25 per cent of the historic wetlands is economically feasible, especially over a 30 year horizon, the social return ratio decreases as the proportion of restoration increase. Full restoration, for instance, does not appear to be an economically attractive option due to high costs.

6.3 Sensitivity Analysis

A sensitivity analysis determines how responsive the analysis is to changes in the input variables (i.e., the benefit estimates, opportunity costs, and restoration costs). In particular, it is useful to know how much a particular variable must change to provide a 1:1 investment ratio. Under the retention scenario, this ratio occurs when opportunity costs and economic benefits are equal. Under the 25 per cent restoration scenario, a 1:1 ratio occurs when economic benefits decrease by approximately half, or opportunity costs per hectare double. As in the main analysis, full retention provides the greatest economic returns.

7.0 Extrapolation of Results

The representativeness of the Black River subwatershed allows for the extrapolation of the study's findings to the full Lake Simcoe watershed, and beyond to rest of southern Ontario. This is important because the entire region is facing development pressures, and the remaining natural areas are becoming increasingly fragmented and degraded. Furthermore, urban and agricultural nutrient loading impact drinking water sources across the Great Lakes basin (OMOE 2011).

The Southern Ontario Wetland Conversion Analysis (DUC 2010) reports that approximately 600,000 hectares of wetlands existed in southern Ontario in 2002, while Wilson (2008) estimated that 38,974 hectares of wetlands currently remain in the Lake Simcoe watershed. Assuming that the wetland phosphorous reduction characteristics that were measured in the Black River subwatershed are representative, losing all the existing wetlands in the Lake Simcoe basin would increase phosphorous loading to the Lake by approximately 242 tons[25] annually, nearly 6 times the 44 ton/yr target. Complete loss of the existing wetlands in southern Ontario would result in an annual 3,732 ton/yr increase to lakes across the region. If all wetland services provided in the SROI analysis (Section 6.2.2) are considered under a thirty year timeframe, the retention of the existing riparian wetlands generates a net benefit of $784.7 million and $12.1 billion for the Lake Simcoe basin and all of southern Ontario, respectively (Table 13).

Table 13. Benefit and cost comparison of thirty year wetland retention extrapolated to the Lake Simcoe watershed and entire southern Ontario region.

Location	Total Benefits	Total Costs	Net Present Value	SROI
Lake Simcoe Watershed (38,974 ha)	1.1 billion	294.7 million	784.7 million	3.66
Southern Ontario (600,000 ha)	16.6 billion	4.5 billion	12.1 billion	3.66

8.0 Public Demand

As our scientific understanding of the wetland benefits to society increase, so too are the efforts to present this information to the general public[26]. It is critical that the public understand the value of wetlands; however, this is generally not the case. The most recent survey data indicates that 70% of respondents are not aware of these benefits, or the alarming loss that is occurring (Lantz et al 2010).

This lack of awareness should not be construed as apathy. Residents of Ontario have expressed their deep concern for their drinking water quality and quantity and residents of the Lake Simcoe watershed are concerned about the effects of phosphorous loading to their lake. Evidence from the Black River study shows that wetland loss has contributed to these trends which indicates that public demand exists for the services that wetlands provide. An informed public is an empowered public. If the public was informed of the environmental and economic benefits that wetlands provide by retaining phosphorous and contributing to the quality of the outdoor recreation and tourism industries, we believe there would be less threat and greater demand for wetland conservation.

9.0 Conclusions and Recommendations

This report presents a compelling business case for wetland conservation in the Black River subwatershed of Lake Simcoe. It provides the most current understanding of wetland loss, the societal benefits, restoration in the subwatershed and opportunity costs of wetland retention and restoration. It is based on two recent studies: the Southern Ontario Wetland Conversion Analysis (DUC 2010) and the Provision of Ecological Goods and Services in the Black River Subwatershed (Yang et al 2011). The results of these studies, and other studies representing wetlands values across southern Ontario, have been combined to generate a social return on investment analysis.

Riparian wetlands in the Black River subwatershed would filter between 0.54 and 6.22 kilograms of phosphorous per hectare annually, depending on the degree of wetland loss or restoration. The full restoration of historic wetlands would provide approximately $315,632 in phosphorous removal benefit, based upon local filtration costs. Although the cost for restoring lost wetlands and for retaining the existing inventory of wetlands is greater than the derived phosphorous reduction benefit, the further drainage of wetlands is also clearly undesirable because it will result in a significant increase in the phosphorous loading to Lake Simcoe. Phosphorous would increase by as much as 891 per cent if all existing wetlands were removed. Continuing to lose these wetlands while considering expenditures on filtration upgrades at the Sutton WPCP does not make economic sense.

When the economic value of capturing nitrogen runoff, carbon sequestration, biodiversity, and tourism are included in the analysis, wetland retention and low levels of restoration can provide a positive return on investment for society. For instance,

25 38,974 hectares multiplied by 6.22 kg/ha/yr increase in phosphorous loading under 100 per cent wetland loss (Table 2).

26 As evidenced by initiatives from Ducks Unlimited Canada, Credit Valley Conservation Authority, Lake Simcoe Region Conservation Authority, Friends of the Greenbelt, etc.

a dollar invested in retention produces $3.66 of value, while a dollar invested in the restoration of up to 25 per cent of the subwatershed's wetlands produces $2.01 worth of value. The diminishing returns relative to the high cost of restoration, when restoration surpasses 25 per cent, creates a strong argument for investing in the prevention of further wetland loss. These are conservative estimates because the analysis did not include the economic value of flood control, erosion control, and groundwater filtration because of a lack of available data.

These results indicate that wetland retention is a key component in limiting phosphorous loading and further environmental degradation to Lake Simcoe. Not only do healthy wetlands generate a net economic benefit for society, their continued loss will significantly increase the phosphorous loading to the Lake. Should this be permitted to occur, it would significantly affect the benefit of the financial investment of local water treatment facilities and agricultural BMP's in the region.

The public must be informed of the services that wetlands provide, and that wetland retention and low levels of restoration provide a net economic benefit for society. While awareness of this reality is growing among policy-makers and the conservation community, studies suggest that a high proportion of the public are simply unaware of the rates of wetland loss, or its consequences (Lantz et al 2010). The low awareness measured in this subwatershed likely reflects much of southern Ontario, and may underestimate the lack of awareness among urban residents who do not live and work in rural areas. This must change because public awareness and support for wetland conservation is necessary to motivate government action and investment that prevents further wetland loss.

Wetlands provide benefit to all Ontarians, and the Provincial government should ensure that a strong and effective policy and regulatory framework is in place that stops further wetland loss and enables restoration. The benefits transcend municipal boundaries, and the costs associated with wetland retention and restoration may be prohibitive for local governments and individuals. Governments should strategically invest in wetland restoration by partnering with conservation organizations. Provincial action is required to ensure that vital wetland services in southern Ontario are maintained.

Photo courtesy of LSRCA

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Appendix A: Biophysical Provision of EGS from Black River Wetlands

The following table describes the results from Yang et al (2011)'s research in the Black River subwatershed showing the provision of EGS with the existing amount of wetland, and six wetland loss and wetland restoration scenarios.

Table A.1
A summary of EGS provision in Black River under existing, loss and restoration scenarios (Yang et al 2011).

Scenarios	Unit	Rest100	Rest75	Rest50	Rest25	Rest10	Rest5	Existing	Loss5	Loss10	Loss25	Loss50	Loss75	Loss100
Wetland area	ha	11237	10325	9414	8502	7955	7773	7590	7211	6831	5693	3795	1898	0
Change of wetland area	ha	3647	2735	1824	912	365	183	0	-379	-759	-1897	-3795	-5692	-7590
	%	48.05	36.03	24.03	12.02	4.81	2.41	0.00	-4.99	-10.00	-24.99	-50.00	-74.99	-100.00
Flow volume	$10^6 m^3/y$	64.78	65.31	65.86	66.44	66.80	66.93	67.06	67.21	67.37	67.87	68.75	69.82	71.53
Sediment load	t/y	737	801	860	952	1030	1066	1126	1167	1224	1400	1789	2605	3957
TN load	t/y	36.70	38.03	40.79	44.64	47.74	49.32	51.15	53.22	55.33	62.02	75.32	104	184
TP load	t/y	3.34	3.56	3.79	4.27	4.76	4.93	5.30	5.65	6.05	7.55	11.65	22.91	52.54
Recharge	mm	105.2	104.2	103.2	102.3	101.7	101.5	101.3	100.6	99.9	97.9	94.5	91.1	87.8
Change of flow volume	$10^6 m^3/y$	-2.28	-1.75	-1.20	-0.62	-0.26	-0.13	0.00	0.16	0.31	0.81	1.69	2.76	4.47
	%	-3.40	-2.61	-1.79	-0.93	-0.39	-0.19	0.00	0.23	0.46	1.21	2.53	4.11	6.67
	$m^3/ha/y$	-626	-639	-657	-683	-714	-714	0	412	410	428	446	484	589
Change of sediment	t/y	-388.8	-325.1	-265.6	-174.1	-96.4	-59.9	0.0	40.8	98.3	274.3	663	1479	2831
	%	-34.52	-28.87	-23.59	-15.46	-8.56	-5.32	0.00	3.62	8.73	24.36	58.86	131	251
	kg/ha/y	-107	-119	-146	-191	-264	-327	0	-108	-129	-145	-175	-260	-373
	mg/l	11.38	12.26	13.07	14.33	15.41	15.93	16.79	17.36	18.17	20.63	26.02	37.31	55.32
Change of TN load	t/y	-14.46	-13.13	-10.36	-6.51	-3.41	-1.84	0.00	2.07	4.17	10.87	24.17	53.23	133.24
	%	-28.26	-25.66	-20.26	-12.73	-6.67	-3.59	0.00	4.04	8.16	21.24	47.25	104.06	260.47
	kg/ha/y	-3.96	-4.80	-5.68	-7.14	-9.35	-10.04	0.00	5.45	5.50	5.73	6.37	9.35	17.55
	mg/l	0.57	0.58	0.62	0.67	0.71	0.74	0.76	0.79	0.82	0.91	1.10	1.50	2.58
Change of TP load	t/y	-1.96	-1.74	-1.51	-1.03	-0.54	-0.37	0.00	0.35	0.75	2.25	6.34	17.61	47.24
	%	-36.97	-32.80	-28.56	-19.41	-10.23	-6.97	0.00	6.58	14.13	42.47	119.63	332.10	890.90
	kg/ha/y	-0.54	-0.64	-0.83	-1.13	-1.49	-2.02	0.00	0.92	0.99	1.19	1.67	3.09	6.22
	mg/l	0.052	0.055	0.058	0.064	0.071	0.074	0.079	0.084	0.090	0.111	0.169	0.328	0.735
Change of recharge	mm	3.93	2.95	1.97	0.99	0.4	0.2	0	-0.67	-1.34	-3.36	-6.74	-10.12	-13.51
	%	3.88	2.91	1.95	0.98	0.40	0.20	0.00	-0.66	-1.32	-3.32	-6.66	-9.99	-13.34
	$m^3/ha/y$	348	348	349	350	354	353	0	571	570	572	573	574	575

Table A.2
Estimated wetland benefits per ha under current condition.

Item	TSS	TN	TP
Unit	t/y	t/y	t/y
Without wetlands	2,993	124,338	30,268
With wetlands	1,126	51,150	5,300
Difference	1,867	73,188	24,968
t/ha/y	0.25	0.00964	0.00329
kg/ha/y	250	9.64	3.29

Appendix B: Summary of Wetland Valuation Literature in Southern Ontario.

Several papers in southern Ontario provide economic estimates of wetland values. Due to their time and financial constraints, the values cited in most of these studies are not specific to a particular local watershed. Rather, they are derived using the benefits transfer method, whereby EGS and associated values from comparable watersheds across North America and Europe are adjusted and applied to southern Ontario. While this is an acceptable approach in environmental valuation literature, precision is lost. To date only one primary contingent valuation study on wetland benefits has been conducted in southern Ontario (Lantz et al 2010). A brief description of results from each study is provided below.

Wilson (2008) provided quantification of EGS in the Lake Simcoe watershed using the benefits transfer methodology. In the report *Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services* for the Lake Simcoe Region Conservation Authority and The Friends of the Greenbelt Foundation, wetland values were estimated at $435 million per year ($11,172 per hectare).

In 2009 the Ontario Ministry of the Environment commissioned the report *Estimating Ecosystem Services in Southern Ontario* (Troy and Bagstad 2009). Using the Natural Assets database and the benefits transfer methodology, this paper determined that non-urban and non-coastal wetlands were annually valued at $15,171 per hectare (urban and suburban wetlands were $161,420).

Credit Valley Conservation (CVC) has been very active in prescribing economic values to natural ecosystems. In 2008 and 2009 they employed DSS Management Consultants for two economic studies: *Valuation of Angling (DSS 2008)* and *Property Value Appreciation: Impacts of Natural Features* (DSS 2009). Using the product travel cost approach, the total annual value of the Credit River fishery is estimated to be in the order of $1.2 million (cumulative NPV of $48 million). In their second study property value appreciation was estimated at 2.4-3.6% ($8,000-10,000) over base value using a hedonic analysis methodology; natural features increased property values by approximately $127.6 million in south Missasauga alone. No research on property value appreciation in response to natural features has been conducted in the Black River subwatershed.

In 2009 CVC produced *Natural Credit: Estimating the Value of Natural Capital in the Credit River Watershed* (Kennedy and Wilson 2009). Using the benefits transfer approach, this study cites the minimal annual flow of wetland EGS values in the Credit River watershed at $187 million ($31,689 per hectare). Wetlands and other natural ecosystems currently provide natural filtration for the drinking water of the watershed's residents. If this capacity was lost, the cost to provide drinking water from Lake Ontario at current consumption rates would be approximately $100 million.

In 2010 CVC conducted the first contingent valuation study, *Valuing Wetlands in southern Ontario's Credit River Watershed*, which estimates willingness-to-pay (WTP) for wetland retention and restoration in the watershed in the range of $220.9 million (retention) to $250.4 million (full restoration). Per hectare values are not provided, but total WTP estimates can be used to justify the scope of a project given the opportunity and restoration cost, such as land purchase, restoration work, monitoring, etc. While this is the only contingent valuation CV study in the region, a limitation is that quantified biophysical EGS from the Credit River was not available on which to base results.

Another resource is the Alternative Land Use Services (ALUS) pilot project implemented in Norfolk County, Ontario. Their website indicates that ecosystem services provided to society by wetlands and other forms of natural capital have been estimated at approximately $3,487 per hectare (ALUS 2011).

Table B.1 Estimated economic value of wetlands in southern Ontario from current literature

Location	Author	Year	Service	Annual Per Hectare Value	Total Annual Value
Lake Simcoe Watershed	Wilson (2008)	2008	Flood Mitigation	$4,039	$157.4 million
	"		Nutrient Reduction	$2,148	$83.7 million
	"		Carbon Sequestration	$524-$1,302	$21.9 million
	"		Biodiversity	$5,830	$247 million
	"		**Total EGS**	**$11,172**	$435 million
Southern Ontario	Troy and Bagstad (2009)	2009	Recreation	$3,551	-
	"		Aesthetic	$6,446	-
	"		Other Cultural	$2,286	-
	"		Biodiversity	$75	-
			Atmospheric Regulation	$14	-
			Water Quality	$2,779	-
	"	2009	**Total EGS**	**$15,171**	-
CVC Natural Capital	Kennedy and Wilson (2009)	2009	**Total EGS**	**$31,689**	$187 million
CVC Contingent Valuation	Lantz et al (2010)	2010	WTP	n/a	$220-250 million
ALUS Pilot	Website 2011	2011	-	$3,487	-

Appendix C: Overview of Wetland Restoration and Retention Costs in Southern Ontario.

Ducks Unlimited Canada (DUC) has extensive experience with wetland restoration. The costs outlined in Table C.1 are those applicable to the typical wetland restoration project that DUC delivers in southern Ontario. Direct and indirect construction costs are those associated with the actual construction equipment, labour and materials. Pre-construction indirect costs are those associated with conservation staff identifying candidate sites, negotiating with landowners and designing the restoration project. Engineering design and permitting are also a component of these costs. Future management costs (FMC) are those associated with the ongoing operation and maintenance of the project into the future (usually over a 20-30 year term). Administration costs are those incurred during the development of the wetland restoration project. This "full cost accounting" approach results in a wetland restoration cost that is much higher than figures used historically and therefore affects the cost:benefit analysis.

Table C.1
The component costs of wetland restoration on a per hectare basis in southern Ontario (DUC 2011).

Wetland Restoration Components	Wetland Restoration Costs ($/hectare)
Direct and indirect construction costs	13,832
Pre-construction indirect costs	8,645
FMC	3,458
Administration	1,729
Total	27,664

Estimates of opportunity costs in the scientific literature for southern Ontario are limited and apply only to agriculture land uses. Opportunity costs reflective of urban development scenarios that would be applicable to the portions of the Black River subwatershed potentially affected by urban sprawl, have yet to be researched. Brethour et al (2001) compares gross margins and fixed costs for several crop varieties to estimate an opportunity cost for marginal farmland. The Alternative Land Use Services (ALUS) pilot project in Norfolk County uses land rental rates as a proxy, providing landowners $371 per hectare annually for beneficial management practices (BMP's) based upon premium land rental rates. The most comprehensive estimates come from Brethour et al (2007), where opportunity costs for agricultural land across Ontario are estimated and presented with land prices and rental rates (Table C.2).

Table C.2
Comparison of land prices, rental rates and opportunity costs for various municipalities across Ontario.

County	Mean Rental Value	Mean Bare Land Sales Value	Opportunity Cost
	$/acre		
Lambton	163	5,625	169
Oxford	168	6,493	169
Bruce	77	3,068	156
Dufferin	57	5,500	156
Grey	46	2,805	156
Huron	180	5,317	156
Perth	200	8,000	156
Simcoe	52	4,227	156
Waterloo	119	7,563	156
Wellington	85	5,569	156
Durham	70	4,829	91
Hastings	57	5,250	91
Kawartha Lakes	25	3,000	91
Northumberland	38	3,500	91
Peterborough	41	2,600	91
Lanark	57	1,750	117

Source: Brethour et al (2007)

Notes

Notes

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