

# 2014 Great Lakes Wetlands Day

PROCEEDINGS | FEBRUARY 4, 2014



GREAT LAKES  
WETLANDS  
Conservation Action Plan

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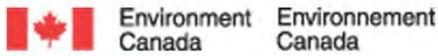
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## PREFACE

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Wetland conservation in the Great Lakes Basin is now more important than ever. The State of Ontario's Biodiversity 2010 reports on the status and trends of 29 indicators related to pressures on Ontario's biodiversity, the state of Ontario's biodiversity, and conservation and sustainable use. The wetland indicator, based on analysis conducted by Ducks Unlimited Canada, revealed that despite their importance, wetlands in the Mixedwood Plains continue to be lost or destroyed due to development. By 2002, the wetland area in southern Ontario was estimated to have been reduced by over 1.4 million hectares (72 percent) of the total pre-settlement wetland area.

The Great Lakes Wetlands Conservation Action Plan (GLWCAP) was developed in 1994 to enable government and non-government partners to work together more effectively to conserve the remaining wetlands in the Great Lakes Basin. Implementation of the GLWCAP is coordinated by a team of representatives from Environment Canada (Canadian Wildlife Service), the Ontario Ministry of Natural Resources, Conservation Ontario, Ontario Nature, the Nature Conservancy of Canada, and Ducks Unlimited Canada.

These organizations and several others in Ontario have complete or ongoing wetland conservation initiatives across Ontario's Great Lakes Basin. These initiatives provide insights into the state of Ontario's wetlands, but are not always readily accessible or known. For GLWCAP to effectively deliver wetland-related priorities, it is important to continually advance our collective understanding of wetland matters in Ontario. On February 4, 2014, a GLWCAP steering committee brought together wetland experts to provide insights on recent advancements in (1) monitoring and research, (2) policy, (3) management, and (4) restoration for wetlands in Ontario's Great Lakes Basin. This document is a compilation of extended abstracts submitted by presenters.

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## MONITORING AND RESEARCH

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*Vegetation dynamics surveys in Lake Ontario  
Photo Credit: Environment Canada*

## Implementing Great Lakes Coastal Wetland Monitoring

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### Introduction

The Great Lakes Coastal Wetlands Consortium (GLCWC) was formed in 2000 in response to calls for indicators of ecosystem health articulated at the State of the Lakes Ecosystem Conferences (SOLEC) in 1996 and 1998. The purpose of the consortium was to develop a Great Lakes basin-wide monitoring program to measure status and trends in ecosystem health for all Great Lakes coastal wetlands. The consortium was facilitated jointly by the Great Lakes Commission and the US EPA's Great Lakes National Program Office (GLNPO) and was made up of 150 scientists, natural resource managers, and policymakers representing 50 US and Canadian organizations.

Consortium researchers determined that indicators of biotic integrity (IBI) held the most promise for measuring coastal wetland health and in 2002 GLCWC scientists conducted pilot studies to develop and test potential indicators. At the same time, the Great Lakes Environmental Indicators (GLEI) group developed a suite of indicators to assess ecological conditions in the coastal margins of all five Great Lakes, though GLEI indicators were not specific to wetlands. After completing these initial studies, GLCWC and GLEI scientists collaborated on the final monitoring plan for Great Lakes coastal wetlands, which was submitted to EPA in March 2008. The collaboration between GLCWC and GLEI researchers ensured that the best possible product for monitoring Great Lakes coastal wetlands was produced. The final monitoring plan included standardized methods for sampling chemical and physical parameters (Uzarski et al. 2008), macroinvertebrates (Uzarski et al. 2004), fish (Uzarski et al. 2005), plants (Albert 2008),

birds (Grabas et al. 2008), amphibians (Timmermans et al. 2008), and surrounding landscape (Bourgeau-Chavez et al. 2008).

In 2010, our team received Great Lakes Restoration Initiative funds from GLNPO to implement a basin-wide coastal wetland monitoring program based on the GLCWC monitoring plan. Twenty-three co-principal investigators from 11 universities across the basin, the Michigan Department of Environmental Quality, the Canadian Wildlife Service, and Bird Studies Canada are participating in the project. Over the 5-year project period (2011-2015), every coastal wetland greater than 4 hectares in size and connected to a Great Lake by surface water will be sampled, equating to over 1000 wetlands. Data on vegetation, macroinvertebrates, fish, amphibians, birds, and water quality are being collected and used to calculate IBI scores for each wetland.

The primary objective of the monitoring program is to inform coastal wetland restoration, management, and protection efforts. Information collected by the program is being used by federal, state, tribal and local government agencies as well as non-governmental organizations to evaluate the success of current wetland restoration projects. Data are also being used to prioritize future protection and restoration efforts. Accordingly, the monitoring program is improving effectiveness and cost-efficiency of coastal wetland management and restoration efforts basin-wide. The purpose of this paper is to provide a summary sampling methodology and to provide initial summarized results from the first three years of the monitoring program.

## Methods

**Site Selection** – The GLCWC developed a stratified-random probabilistic site selection design that allows statistically valid prediction of both status and trends in wetland ecosystem health based on subsets of sites. Therefore, average wetland condition for the entire basin or for smaller sub-regions can be determined from a single year of sampling or from multiple years. Likewise, as the monitoring program progresses, trends in wetland condition can be determined for the entire basin or sub-regions.

Initially, a pool of 1079 wetlands meeting the criteria for sampling was identified from spatial data generated previously by the GLCWC (Fig. 1). These wetlands were assigned to strata based on 1) wetland type (riverine, lacustrine, barrier-protected; Albert et al. 2005); 2) region (northern vs. southern); and 3) Great Lake. Wetlands were then selected randomly from each type x region x lake stratum for each project year (2011-2015) in proportion to the number of wetlands occurring in each stratum. Approximately 20% of the wetlands were assigned to each project year so that all wetlands will be sampled within 5 years. Additionally, beginning in Year 2, approximately 10% of wetlands sampled in the previous year will

be re-sampled. These repeat samplings are used to track temporal trends in ecosystem health. This sampling design was chosen because it ensures that data from each year are representative of wetlands basin-wide and in each stratum and because temporal trends can be measured without causing harm to the wetlands themselves by intensive annual sampling at just a few sites (Urquhart et al. 1998). Each year's list of wetlands is then divided among sampling crews across the basin to maximize efficiency in sampling and to leverage the regional expertise of team members.

Additional wetlands outside of the probabilistic design are also being sampled, enabling us to calibrate indicators at both the 'least-impaired' and 'most-degraded' ends of the anthropogenic disturbance gradient identified by Danz et al. (2005). These "benchmark" sites also include wetlands undergoing or being considered for restoration and/or protection. Data from these wetlands are being used by agency staff and other stakeholders to base management decisions on a site-specific basis. Up to 10% of wetlands sampled in any given year may be benchmark sites that fall outside the probabilistic site selection framework. During the first three years of the project (2011-2013), crews successfully sampled 176, 206, and

201 sites, respectively, for a total of 583 wetlands sampled to date.

**Chemical and Physical Data** – Within each wetland, mono-dominant plant zones are identified for sampling water quality, fish, and macroinvertebrates. Plant zones are patches of vegetation in which a particular plant type or growth form dominates the community based on visual coverage estimates. Other species or growth forms often occur within a given plant zone; however, zones are near-monodominant stands comprised of at least

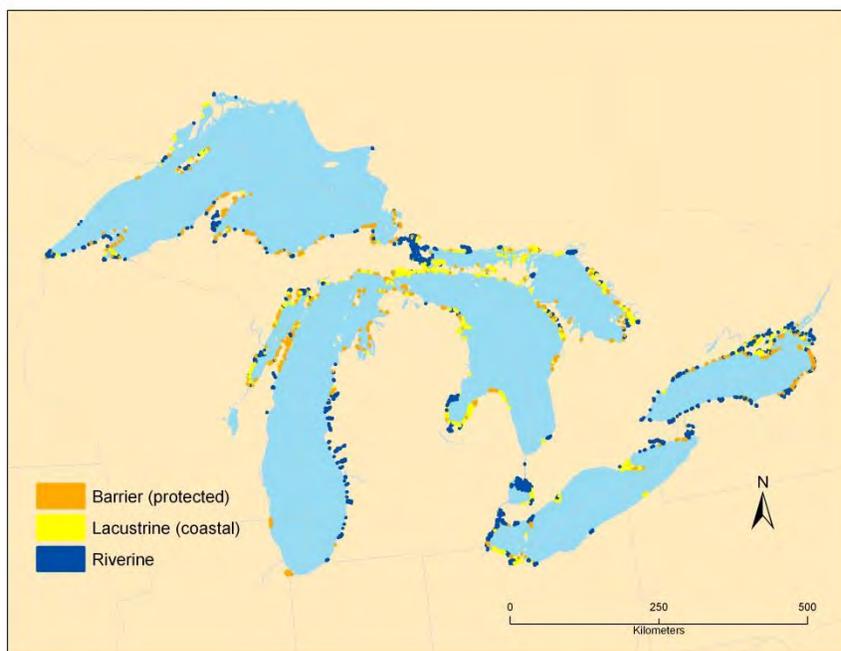


Figure 1. The 1,039 wetlands selected for sampling over the 5 year project (2011-2015), colour-coded by wetland type. Note the profound interaction of lake and wetland type.

75% of one plant type (i.e. genus or species; growth form). Plant zones include *Typha* (cattail), water lily (e.g. *Nuphar* or *Nymphaea*), *Schoenoplectus* (bulrush, including both “dense” and “sparse” zones where they occur), *Peltandra-Sagittaria-Pontederia* (arrow-arum-arrowhead-pickerelweed, combined because of similar growth form), *Sparganium* (bur-reed), wet meadow (mixed vegetation, generally containing *Juncus* and *Eleocharis*), and submerged aquatic vegetation. Stratification by plant zones helps to ensure that within-wetland variability is represented since chemical and physical conditions and community structure tend to vary by vegetation type (Uzarski et al. 2004, 2005).

Chemical and physical data are being collected according to GLCWC protocols (Uzarski et al. 2005, 2008). *In situ* measurements are made at mid-depth using a Yellow Springs Instruments (YSI) Model 6600 multi-parameter sonde or equivalent instrumentation and include temperature, dissolved oxygen, oxidation-reduction potential, total dissolved solids, turbidity, pH, and specific conductivity. Water samples are collected from each plant zone for determination of total alkalinity, total nitrogen, total phosphorus, chlorophyll *a*, soluble reactive phosphorus, ammonium-N, and nitrate-N via standard methods (APHA 2005). Chemical and physical data are important covariates used to explain community structure and to refine IBI metrics.

*Macroinvertebrates* – Macroinvertebrate communities are being sampled from mid-June to early September following GLCWC methods (Uzarski et al. 2004). Sampling is stratified by plant zone within each wetland and three points are sampled per zone. Samples are collected using standard 0.5 mm mesh D-frame dip nets by sweeping through the entire water column and agitating/scraping plant stems and benthic substrate. Net contents at each sampling point are composited and placed into gridded white pans. Macroinvertebrates are then picked systematically with forceps by removing all individuals from one area of the pan before moving on to the next. Picking is conducted until

150 individuals are collected or until 30 person-minutes of effort elapses, after which time picking continues to the next multiple of 50. Specimens are preserved and later identified to the lowest operational taxonomic unit (usually genus or species) in the laboratory.

*Fish* – Fish data are being collected according to GLCWC methods (Uzarski et al. 2005). Fish are collected using three fyke nets per mono-dominant plant zone, set for one night (generally 12-24 hours). Two sizes of nets are being used. Large nets consist of a 7.62 m (l) x 0.91 m (h) lead extending from the opening of a 1.22 m (w) x 0.91 m (h) box with 1.83 m (l) x 0.91 m (h) wings extending from both sides of the box at 45° to the direction of the lead. Two funnels with 0.17 m throats form the trap portion of each net. Small nets consist of a 7.62 m (l) x 0.46 m (h) lead extending from the opening of a 0.91 m (w) x 0.46 m (h) box with 1.83 m (l) x 0.46 m (h) wings extending from both sides at 45° from the direction of the lead. Two funnels with 0.10 m throats form the trap portion of each small net. Both sizes of nets have 3/16” mesh. All captured fish are measured (total length), identified to species, and released alive.

*Vegetation* – Vegetation data are being collected according to GLCWC methods (Albert 2008). In each wetland, three transects are established perpendicular to depth contours and the shoreline. For this indicator, major vegetation zones are defined differently than those used for the other indicators and include wet meadow, emergent, and submersed vegetation zones. Along each transect, five 1 m<sup>2</sup> sampling quadrats are evenly spaced within each zone. Therefore, a maximum of 15 quadrats are sampled per transect if all vegetation zones are present for a maximum of 45 quadrats per wetland. Percent cover for each plant species, total percent vegetation cover, water depth, organic sediment depth, and relative turbidity are recorded for each quadrat. Representative specimens of plants that are not reliably identifiable in the field are preserved for identification in the laboratory.

**Birds** – Birds are being surveyed twice per breeding season according to GLCWC methods (Grabas et al. 2008). Surveys are conducted once during the morning and once during the evening, with a minimum of 10 days between visits. Surveys include timed counts at 1-8 sampling points in each wetland, depending on wetland size, proximity to safe access points, and relative coverage of different habitat types within the wetland. Morning surveys are being conducted between 30 minutes before sunrise and 4 hours after sunrise (morning surveys) and evening surveys are conducted between 4 hours before sunset and 30 minutes after sunset, both in calm weather. At each survey point, the species, approximate distance and direction, and number of individuals of all birds observed (visual or auditory, including birds in flight) are recorded for 15 minutes. The 15-minute survey period includes five minutes of auditory broadcasting to elicit calls from elusive birds including Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), least bittern (*Ixobrychus exilis*), common gallinule (*Gallinula galeata*), American coot (*Fulica americana*), and pied-billed grebe (*Podilymbus podiceps*). Digital audio recordings are made at a subset of sampling points and later compared to observational data to ensure accurate identification of calls.

**Amphibians** – Amphibian data are being collected according to GLCWC methods (Timmermans et al. 2008). Amphibian sampling occurs three times per breeding season, during peak vocalization periods associated with night air temperatures of approximately 5, 10, and 17°C, with a minimum of 15 days between visits. Amphibians are surveyed using timed aural counts. Within each wetland, one to six survey points are established depending on wetland size, proximity to safe access points, and relative coverage of different habitat types within the wetland. Amphibian sampling points are co-located with bird sampling points when possible. Surveys are conducted between 30 minutes before sunset and four hours after sunset in calm weather. At each survey point, the species, approximate distance and direction, and intensity of vocalizations are recorded for a three minute period. Digital audio

recordings are made at a subset of sampling points and later compared to observational data to ensure consistent categorization of calls.

**Data handling and analysis** – A web-based data entry system linked to a PostgreSQL database as the storage back end was developed for the project. A web-based data retrieval system for project researchers has also been developed, giving researchers access to up-to-the-minute project data. Index of biotic integrity scores are being calculated for each set of taxa at each wetland. These IBI scores are used as measures of ecosystem health for wetland management, protection, and restoration purposes. Other analyses (e.g. diversity, occurrence of invasive species, comparisons of community structure between regions, etc.) are being conducted as needed and requested by wetland managers.

Project data at varying levels of resolution are being provided to wetland managers, policy makers, and the public via an online ESRI ArcGIS mapping tool. This is an in-browser application requiring no specialized software on the user's system. Tools for defining user-specified areas of interest provide results in regional and local contexts. Authorized users (e.g. agency personnel and other wetland managers) will be able to drill down to specific within-site information to determine factors driving a site's IBI scores.

## Results

Summary results for fish, macroinvertebrates, vegetation, birds, and amphibians are presented below. Index of Biotic Integrity scores are also presented, though these indicators have been calculated for only a subset of sampled wetlands so far because index formulations are currently being validated for basin-wide use.

**Fish** – Total fish species richness did not differ greatly by lake, averaging 13-15 species per wetland. 55% of wetlands contained no non-native species and 30% had one non-native species. Lake Huron wetlands averaged the lowest mean number of non-native fish taxa (0.6). Individual wetlands with the greatest number of non-native taxa were found on lakes Superior (6), Erie (5), and Michigan (4). It is important to note

that sampling effort was limited to a single night in most cases so these numbers may underestimate non-native fish occurrence. We are currently able to report fish IBI scores for wetlands containing bulrush and/or cattail zones (Fig. 2), the two zone types with GLCWC validated fish IBIs (Uzarski et al. 2005). Only a small number of wetlands rank as “high quality/reference condition” with the fish IBI and many more are categorized as “moderately impacted” or “degraded.”

**Macroinvertebrates** – Based on 2011 and 2012 data, average macroinvertebrate taxa richness per wetland was approximately 44, but some wetlands had more than twice this number. There was considerable variability among lakes in the mean number of macroinvertebrate taxa per wetland. Lake Erie and Ontario wetlands averaged 35.1 and 36.3 taxa, respectively, while wetlands on lakes Huron, Superior, and Michigan averaged 49-50 taxa. There was little variability in mean non-native taxon richness among lakes (1.2-1.6 taxa), though lakes Erie and Huron had wetlands with as many as 4 non-native taxa. At least one non-native macroinvertebrate species occurred in every wetland sampled, emphasizing the widespread distribution of non-native

macroinvertebrate species throughout the Great Lakes. Macroinvertebrate IBI scores (Uzarski et al. 2004) were calculated for wetlands having sparse bulrush (*Schoenoplectus*), dense bulrush (*Schoenoplectus*), and/or wet meadow zones—the three zone types for which macroinvertebrate IBI metrics have been validated (Fig. 3). The lack of IBI results for lakes Erie and Ontario and southern Lake Michigan is due to the wetlands in these areas not having any of the three necessary vegetation zones. We are currently developing IBIs for additional zones to cover these sites.

**Vegetation** – On average, 47 macrophyte species were identified per wetland basin-wide. Lake Huron wetlands had the greatest mean number of species (57.1), with Lake Erie wetlands having much lower mean species richness (26.8) than any of the other lakes. Maximum species richness per wetland was higher in wetlands of lakes Huron (124) and Michigan (105) than the other lakes (78-87 species). Only 10% of 316 wetlands sampled for vegetation basin-wide lacked invasive species, leaving 90% of wetlands with at least one invasive species. Wetlands were most commonly invaded by two to five plant species and 8% of sites contained seven or more invasives. Average invasive plant species richness per wetland was highest in lakes Ontario (5.3) and Erie (4.3), and lowest in Lake Superior (1.6). The Floristic Quality Index (FQI) was calculated for wetlands across the basin and FQI scores were used as the vegetation IBI (Fig. 4). In general, wetlands with low FQI scores were concentrated in the southern Great Lakes, where there are large amounts of both agriculture and urban development, while sites with high FQI scores were concentrated in the northern Great Lakes.



Figure 2. Condition of coastal wetland fish communities at sites with bulrush or cattail zones. The indicator is labeled “draft” while more zone IBIs are developed. Based on data from 2011 through 2013.

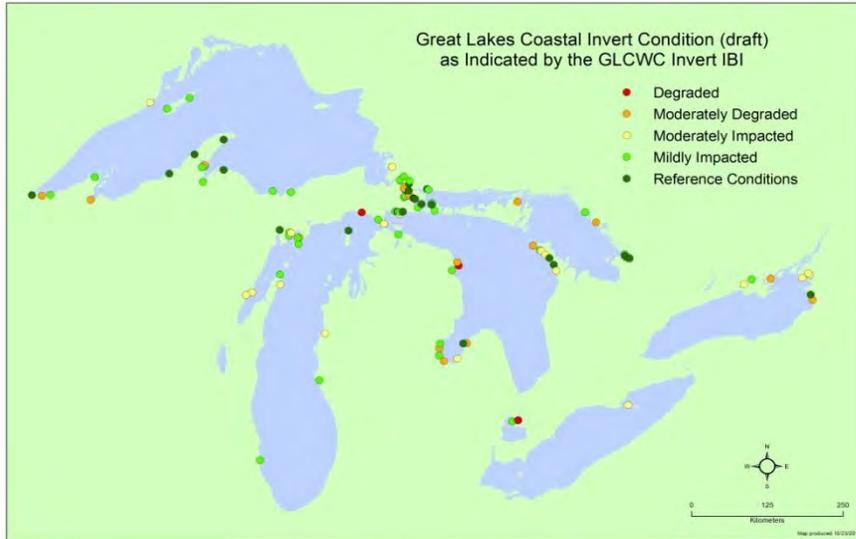


Figure 3. Condition of coastal wetland macroinvertebrate communities at sites with bulrush or wet meadow zones. The indicator is labeled “draft” while additional zone IBIs are developed. Based on data from 2011 and 2012.

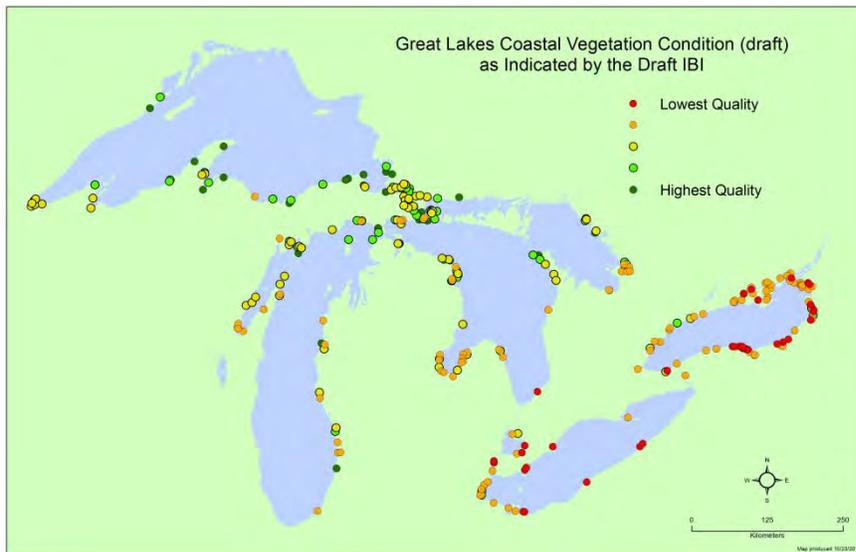


Figure 4. Condition of coastal wetland vegetation at sites across the Great Lakes. The indicator is labeled “draft” while the effect of recent taxonomic revisions on IBI scores are investigated. Based on data from 2011 through 2013.

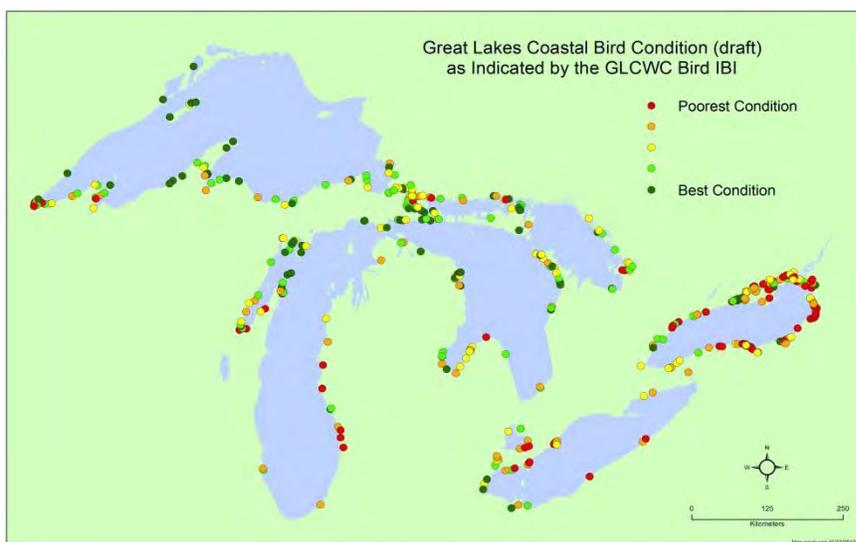


Figure 5. Condition of coastal wetland bird communities. The indicator is labeled “draft” while we determine whether enough adjustment has been made for latitudinal variability. Based on data from 2011 through 2013.

*Birds* – An average of 25 bird species were observed per wetland basin-wide, though species richness ranged from 2-68. Lake Ontario wetlands had the lowest average bird species richness (19.5) while Lake Superior wetlands had the highest (30.1) and lakes Huron, Michigan, and Erie were intermediate (25-27 species per wetland on average). Bird IBI scores were calculated according to Crewe and Timmermans (2005; Fig. 5). This IBI is considered “draft” because our data expand the IBI beyond the area where it was developed. We are currently analyzing whether adjustments sufficiently account for differences due to latitude across the entire Great Lakes basin. Though there is substantial variability in bird IBI scores within each lake, wetlands on lakes Erie and Ontario fare the poorest overall. However, some wetlands on the upper lakes such as those near Duluth, MN, on Lake Superior, also had low bird IBI scores.

*Amphibians* – There are relatively few calling amphibian species in the Great Lakes (eight in total) and coastal wetlands averaged approximately four species per wetland basin-wide. Some wetlands contained just a single calling species (almost always spring peeper, *Pseudacris crucifer*); however, there were wetlands where all eight species were observed over the three sampling dates. Wetlands averaged three to four calling amphibian species regardless of lake. Similarly, there was little variability by lake in maximum or minimum numbers of species observed. We have had some success in developing an amphibian-based indicator using spring peeper density, though this indicator has not been validated so is not included here.

### Discussion

The first three years of coastal wetland monitoring has revealed a number of trends in ecosystem health. In general, wetlands in the lower and more southern lakes (Erie and Ontario) had lower IBI scores than wetlands of the upper lakes. This pattern was most apparent for vegetation, bird, and fish-based indicators and occurred on both the Canadian and US sides of the lakes. A similar latitudinal gradient was

evident within Lake Michigan, with higher IBI scores in the northern half of the lake than the southern half of the lake. The trend of healthier wetland ecosystems in the north and impacted wetlands in the southern portion of the basin is consistent with latitudinal gradients in watershed agriculture and developed land (Danz et al. 2007) and gradients in overall anthropogenic stressors (Allan et al. 2013).

While there was a general trend of increasing ecosystem health with increasing latitude, a number of northern areas also appeared to be quite impacted based on their relatively low IBI scores. Inner Green Bay wetlands (northern Lake Michigan), for example, had lower fish, bird, and vegetation IBI scores than other wetlands in the same region. This is likely due to the high percentage of agricultural and urban land uses in the Green Bay watershed. Similarly, the St. Louis River Estuary near Duluth, MN on western Lake Superior had wetlands with relatively low vegetation and bird IBI scores, likely due to impacts associated with watershed agriculture, surrounding urbanization, and intense shipping activities within the Duluth-Superior Harbor.

In Ontario, wetlands on Lake St. Clair and western Lake Erie tended to have low IBI scores, especially for vegetation and birds. Many of these wetlands were completely dominated by invasive *Phragmites australis*, which degrades habitat quality substantially. While the majority of wetlands on the Canadian side of lakes Erie and Ontario had low IBI scores for vegetation and birds, a few wetlands, especially in northeastern Lake Ontario, had relatively high IBI scores suggesting that high quality wetlands still exist in these areas. On the Canadian side of Lake Huron, The majority of wetlands sampled in Georgian Bay and on the Bruce Peninsula also had relatively high IBI scores, suggesting that these areas continue to harbour high quality wetlands.

Our monitoring data has also revealed that the different taxonomic groups respond to conditions at different spatial scales. For example, our vegetation IBI data show relatively little within-region spatial variability and wetlands that are

adjacent to one another tended to have similar vegetation IBI scores. Macroinvertebrates and fish, on the other hand, appear to indicate conditions at more localized scales and adjacent wetlands often had very different IBI scores likely due to the response of these communities to localized impacts. This suggests that the IBIs are complimentary in estimating overall ecosystem health so applying them in concert will yield the most accurate picture of wetland health.

Coastal wetland management efforts, especially Great Lakes Restoration Initiative (GLRI) projects, have much to gain from comprehensive monitoring data. Our project is providing information to numerous GLRI projects and many other restoration and management efforts across the basin. In addition to ongoing sampling of wetlands basin-wide, we are expanding our IBIs to include all major vegetation types found throughout the basin. These expanded IBIs will provide an even more complete picture of coastal wetland ecosystem health basin-wide to support restoration and protection of these critical coastal resources.

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## Factors Affecting Use of Wetland Habitat by Fish and Wildlife in Coastal Wetlands of Georgian Bay

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### Introduction

Great Lakes coastal wetlands are productive ecosystems supporting a high diversity of freshwater species. The majority of these wetlands have been lost or degraded as a result of human disturbance; however, most coastal wetlands in Georgian Bay (Lake Huron) remain abundant and in pristine condition (Cvetkovic and Chow-Fraser 2011). The McMaster Coastal Wetland Inventory (MCWI) reveals that there are more than 3700 aquatic marshes in eastern and northern Georgian Bay, and almost 90% of these are < 2 ha in size (Fig. 1; Midwood et al. 2012). Despite their small size, they provide high-quality reproductive and foraging habitat for fish and wildlife, including species at risk. These coastal wetlands are typically low nutrient and dystrophic, reflecting inputs from forested

catchments on Precambrian Shield bedrock, and minimal human settlement along the Georgian Bay coast (DeCatanzaro and Chow-Fraser 2011). Their hydrology and water chemistry are also heavily influenced by large-lake processes through direct hydrological connection that lead to large variations in water levels on a daily, seasonal and annual basis. These hydrologic connections play an important role in maintaining aquatic biodiversity in the wetlands by preventing monocultures of emergent vegetation from forming, by facilitating frequent exchange of chemical constituents between the wetlands and lakes, and by allowing daily and seasonal migration of fish in and out of the wetlands (Fracz and Chow-Fraser 2013a). The coastal wetlands of Georgian Bay are still among the least human-disturbed in the Great Lakes, but expansion of road networks, increases in cottage and residential development, invasion by non-native species, and a sustained drop in water level of close to 1 metre over the past 14 years are threatening the integrity of these sensitive ecosystems.

### Methods

*Wetland Digitizing* – The McMaster Coastal Wetland Inventory (MCWI) was developed by Midwood et al. (2012) to provide a comprehensive dataset of Georgian Bay's unique assembly of pristine coastal wetlands. High-resolution (1 m) IKONOS satellite images of the entire eastern coast of Georgian

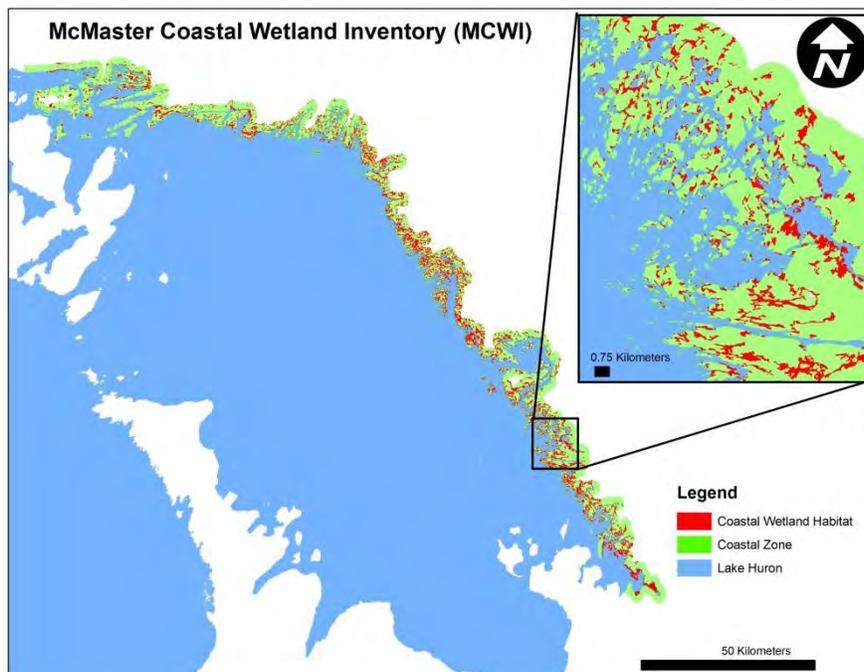


Figure 1. Map showing all coastal wetland habitat (red) and coastal zones (green) of eastern and northern Georgian Bay within the McMaster Coastal Wetland Inventory (MCWI; Midwood et al. 2012).

Bay from 2002-2008 were used to manually delineate wetland boundaries on ArcGIS 9.2 (ESRI™, Redlands, CA, USA). To make this inventory useful for monitoring changes in fish habitat, wetlands were digitized into low-marsh (permanently inundated fish habitat), high-marsh zones (seasonally inundated meadow habitat), and upstream habitat.

*Wetland Indices* – The literature indicates that a negative relationship exists between wetland health and anthropogenic activity (Minns et al. 1994, Trebitz et al. 2007, Danz et al. 2007, Morrice et al. 2008). Cvetkovic and Chow-Fraser (2011) compared the health of 181 coastal marshes across all 5 Great Lakes sampled over a 13-year period (1995-2008) using three published ecological indices developed specifically to evaluate coastal wetlands in the Great Lakes: the Water Quality Index (WQI; Chow-Fraser 2006), the Wetland Macrophyte Index (WMI; Croft and Chow-Fraser 2007), and the Wetland Fish Index (WFI; Seilheimer and Chow-Fraser 2007). Water quality parameters were measured at all sites, including primary nutrients (phosphorus and nitrogen), water clarity (chlorophyll), total suspended solids, total inorganic suspended solids, turbidity, as well as physical parameters (temperature, pH, conductivity). Each site was

surveyed and identified for macrophytes following the methods outlined by Croft and Chow-Fraser (2007, 2009), and paired fyke nets (two large sets, one small) set parallel to shore were deployed to assess the fish community following a standardized protocol described by Seilheimer and Chow-Fraser (2007). These data have been used to calculate scores for their associated indices, and were used to compare wetland quality across the Great Lakes Basin.

*Comparing Historic Water Levels to Coastal Wetland Habitat* – Water levels in Lake Huron have been declining over the past decade (Fig. 2). This has altered wetland plant assemblages in Georgian Bay coastal wetlands that provide critical fish and wildlife habitat. Midwood and Chow-Fraser (2012) compared IKONOS satellite images of eastern Georgian Bay from different years (2002 and 2008) to identify changes in wetland vegetation (meadow, emergent, high-density floating, and low-density floating) associated with decreasing water levels. Since 1999, water levels have persisted at extremely low levels, and this has resulted in many of the coastal wetlands being disconnected hydrologically from Georgian Bay. Fracz and Chow-Fraser (2013a) applied a site-specific approach to determine the amount of fish habitat

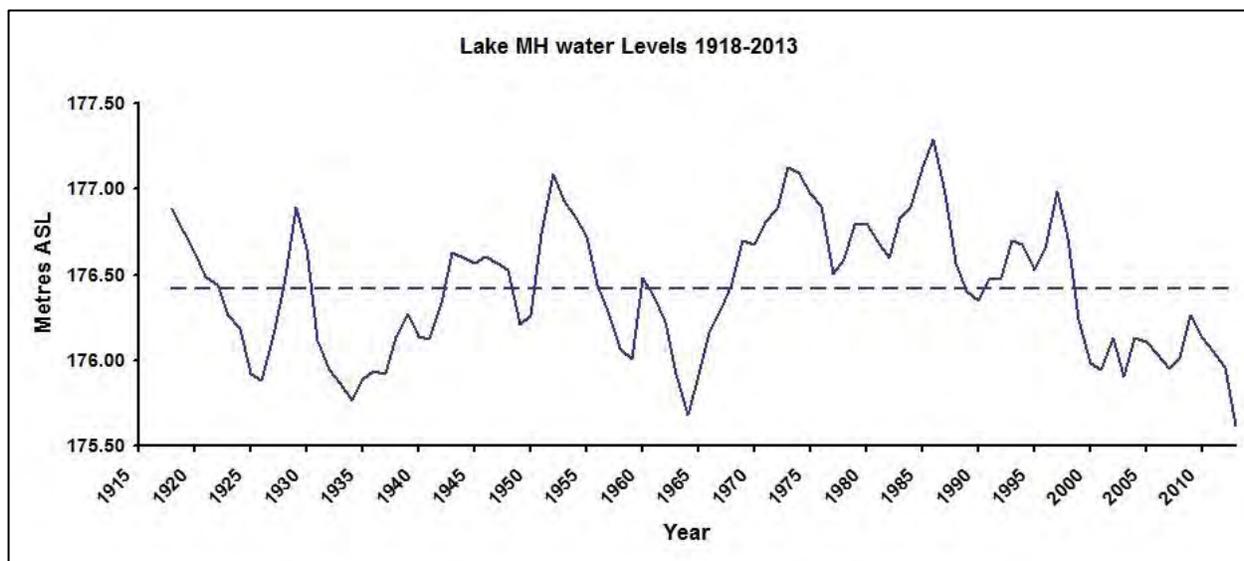


Figure 2. Mean annual water levels for Lake Huron from 1918 to 2013. The dotted line indicates the average water level for this time period. Persistent low water levels below average are observed over the last decade. Data were obtained from National Oceanic and Atmospheric Administration (NOAA; 2013).

in seven representative wetlands of eastern Georgian Bay, and was able to calculate the amount of fish habitat that has been lost between high water levels and the current low water levels. They also used a regional model to predict the magnitude of habitat loss if water levels were to continue to decrease. To study the effect of hydrological disconnection on the water chemistry of coastal marshes, Fracz and Chow-Fraser (2013b) sampled 34 coastal marshes in protected embayments (forested watersheds, minimal human disturbance), 17 of which were beaver-impounded. They used a YSI 6600 multiprobe (YSI, Yellow Springs, Ohio) to measure pH and conductivity at all sites, while turbidity was measured with a turbidimeter (LaMotte, Chestertown, Maryland, USA). Nutrient samples were also collected and analyzed, and included total nitrate nitrogen (TNN), total ammonia nitrogen (TAN), total suspended solids (TSS), total phosphorus (TP), and soluble reactive phosphorus (SRP). They compared water chemistry in a beaver-impounded wetland both above and below the dam to determine the effects of impoundment on water chemistry in coastal marshes.

**Results**

*Inventory of Georgian Bay Coastal Wetlands* – The MCWI (Midwood et al. 2012) determined that four times as many wetland complexes exist in eastern and northern Georgian Bay (> 700) than had previously been included in the Great Lakes Coastal Wetlands Consortium (GLCWC) inventory. Results revealed that there are over 3700 aquatic marshes along the shoreline of eastern and northern Georgian Bay, 90% of which are < 2 ha (a size restraint that excluded these from GLCWC inventory). To date, the MCWI is the most comprehensive inventory of coastal wetlands in eastern Georgian Bay, providing

zonal habitat separation allowing long-term changes in fish and plant communities to be monitored and compared.

*Coastal Wetland Quality Across the Great Lakes Basin* – The health of Great Lakes coastal marshes is directly related to the extent of anthropogenic activities, such as urbanization and agricultural development in the region. WQI, WMI, and WFI scores gave an indication of the general condition of the wetlands. Statistical analyses indicated that wetland quality between the Great Lakes differed significantly. WQI scores for each Great Lake revealed that > 50% of marshes in lakes Michigan, Erie, and Ontario were in degraded condition, while over 70% of marshes in Lake Superior, Lake Huron, and Georgian Bay were minimally impacted. The highest proportion of very good and excellent quality wetlands, and the least number of degraded wetlands existed in Georgian Bay (Fig. 3).

*Hydrologic Disconnectivity* – Sustained low water levels in the recent decade have significantly impacted vegetation and fish assemblages in coastal wetlands of eastern Georgian Bay (Midwood and Chow-Fraser 2012). Between 2002 and 2008, we saw a significant decrease in low-

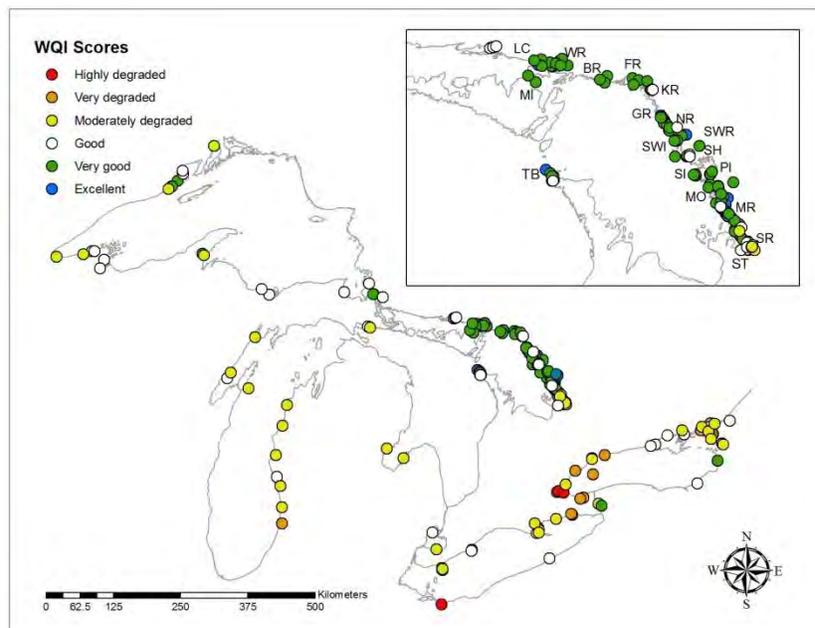


Figure 3. Comparison of **WQI** scores across 181 coastal wetlands sampled between 1995 and 2008. Inset is an expansion of Georgian Bay with the highest scores (figure taken from Cvetkovic and Chow-Fraser 2011).

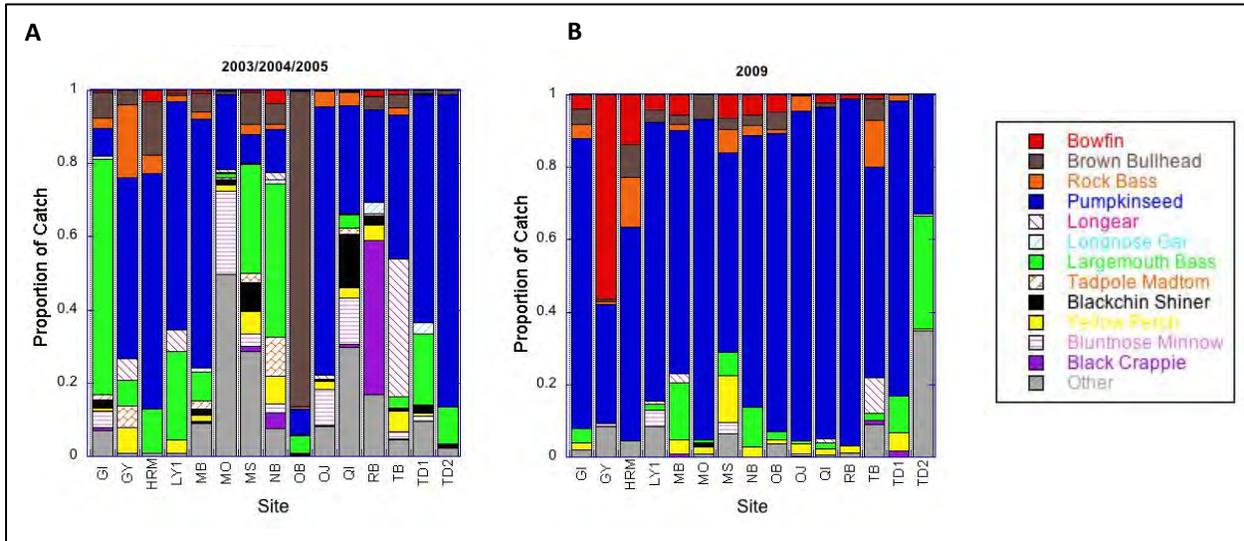


Figure 4. Proportion of catch represented by each species in each wetland sampled in a) 2003-2005 and b) 2009. Figures indicate a significant decrease in species richness from the early to late sampling period (figure taken from Midwood and Chow-Fraser 2012).

density floating vegetation with a concomitant increase in meadow and high-density floating vegetation. A greater coverage of high-density floating vegetation also replaced small patches of low-density floating vegetation. These changes coincided with a decrease in species richness of the fish community, along with a shift in species composition, with a significant increase in

pumpkinseeds and bowfin species with declining water levels and a decrease in largemouth bass, blackchin shiner and tadpole madtom (Fig. 4).

Fracz and Chow-Fraser (2013a) determined the relationship between amounts of wetland habitat that would be stranded (i.e. no longer connected to Georgian Bay) as a function of declining water levels (Fig. 5). The greatest rate of wetland stranding is associated with water levels between 173.5 and 176.5 m asl. For all seven wetlands surveyed, an average loss of 24% surface area between 2010 (176.11 m) and the historic water level high (177.5 m) has already occurred. If water levels were to drop to 174.0 m, as predicted by the Global Circulation Models (GCM), access to an additional 50% of the wetlands would be lost. The record low water level of 175.7 m reported in January 2013 was associated with a loss of 12% compared to 2010 levels. Hydrologic disconnectivity due to beaver impoundments prevented water in embayments to be mixed with open water of Georgian Bay, and led to significantly higher concentrations of TP, SRP, TSS, turbidity, and chlorophyll, but significantly lower pH, nitrates, and conductivity. These results indicate that water chemistry above impoundments in Georgian Bay is nutrient rich and ion-poor, while water before the impoundment was nutrient poor and ion-rich.

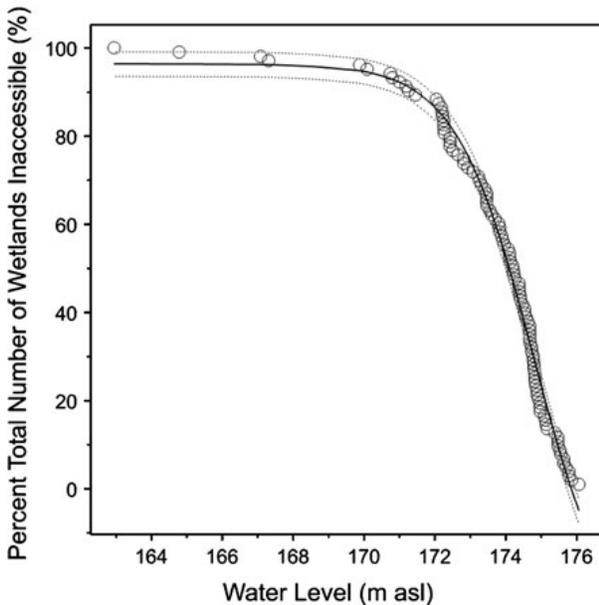


Figure 5. Total number of wetlands (%) that become inaccessible to fish as a function of water level for 103 coastal wetlands in eastern Georgian Bay (figure taken from Fracz and Chow-Fraser 2013).

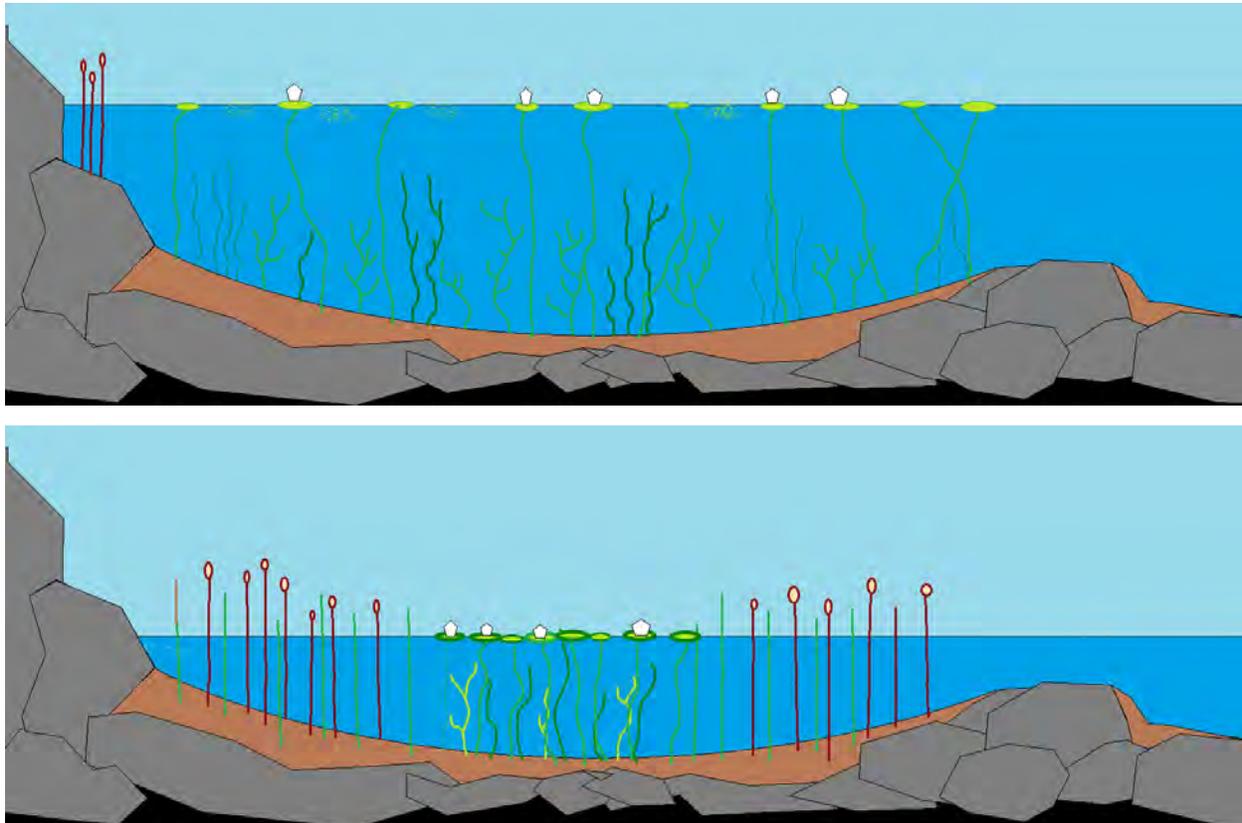


Figure 6. Top panel: Graphic illustrating how wetland vegetation is distributed during high water-level scenarios in a coastal wetland that develops behind a rock-lined sill. Bottom panel: Graphic illustrating how low water levels would lead to decreased habitat complexity and densification of floating and emergent vegetation, with loss of submerged aquatic vegetation (Prepared by D. Taylor).

### Discussion

Climate change is predicted to cause further decline in water levels in the Great Lakes, particularly in Lake Huron (Sellinger et al. 2008). These persistent low water levels will continue to alter vegetation structure and coverage in the coastal wetlands of Georgian Bay. Completion of the MCWI by Midwood et al. (2012) demonstrates how a comprehensive habitat-based inventory of coastal wetlands can be used to provide a regional model of how wetlands would respond to changes in water levels. Monitoring changes in the amount of low-marsh (aquatic) and high-marsh (emergent) allows us to monitor changes in critical habitat for the fish, marsh birds and turtles. Monitoring changes in high marsh habitat will allow us to examine the role played by upstream wetlands in controlling downstream water quality. Water chemistry in coastal wetlands is the result of both dynamic offshore

processes as well runoff from upstream habitat, and can be affected by the morphology of wetland, the size and slope of watersheds, and land use within the watershed such as amount of farmed or forested land and road density (DeCatanzaro and Chow-Fraser 2011). Due to the as yet low level of human impact in most regions in Georgian Bay, water quality scores reveal healthier coastal wetlands compared to the other Great Lakes. Our comparison of wetland quality across the Great Lakes Basin revealed that wetlands in the Lower Great Lakes (Lake Erie, Lake Ontario) where development and human disturbance is highest are also the most degraded (Cvetkovic and Chow-Fraser 2011).

Sustained low water levels over the past 15 years have impacted navigation and local economies, as well as caused large-scale negative ecological impacts on near shore habitats. Decreasing water levels have increased vegetation density and led

to a more homogenous macrophyte community, with a greater abundance of meadow vegetation that was previously aquatic habitat (Fig. 6). This loss of aquatic habitat is problematic for fish, especially when growth of canopy forms of submerged aquatic vegetation (SAV) become scarce, since these wetland plants disproportionately provide shelter and foraging habitat for many fish species. Aquatic habitat that is dominated by dense floating vegetation is less suitable as fish habitat because they are less structurally diverse than either emergent or SAV. The fish communities following the period of low water levels have become increasingly more homogeneous, as indicated by decreased species richness, and this is likely a consequence of reduced habitat complexity in the coastal wetlands (Midwood and Chow-Fraser 2012).

Fracz and Chow-Fraser (2013a) confirmed that declining aquatic habitat from sustained low water levels can lead to a net loss of fish habitat. GCMs indicate that water levels will continue to decline over the next decades, and this will certainly lead to greater losses of wetland fish habitat due to disconnection with Georgian Bay. Since hydrologic disconnectivity of coastal wetlands can result in altered water chemistry (Fracz and Chow-Fraser 2013b), impounded wetlands are expected to be significantly more nutrient rich and ion-poor compared to unimpounded marshes, reflecting reduced mixing with open waters of Georgian Bay. Hence, in addition to being a barrier to spring migrations of Great Lakes fish, impoundments can also affect the distribution of wetland biota through alteration of water chemistry within the marsh. Results of these studies illustrate the importance of routine monitoring programs to track changes in the health of coastal wetlands, so that we can prevent further loss and degradation of critical fish and wildlife habitat in eastern Georgian Bay.

#### **Acknowledgements**

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Coastal Wetland Inventory. Research grants and contracts were provided by the International Joint Commission, Sierra Club Canada Foundation, the Ontario Ministry of Natural Resources and Georgian Bay Forever. I am indebted to Julia Rutledge for outstanding assistance with manuscript preparation and writing, and to Dallas Taylor for permission to use his illustration of aquatic life in a coastal marsh during high and low water-level scenarios. Last but not least, I wish to thank the tremendous encouragement and friendship of Mary Muter, and her generosity in letting our lab unlimited use of her cottages and island throughout the past 10 years to sample the amazing wetlands of eastern Georgian Bay.

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## Durham Region Coastal Wetland Monitoring Project: Monitoring to Management – Making the Connection

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### Introduction

The Durham Region supports a distinct concentration of coastal wetlands on the shores of Lake Ontario which provide unique ecological functions including settlement and retention of sediments and contaminants, filtration of nutrients, and the provision of habitat for wildlife. They also provide recreational and educational opportunities, and protect shorelines from erosion. The Durham Region Coastal Wetland Monitoring Project (DRCWMP) was initiated to conduct a long-term monitoring project that enables reporting on, and comparisons of, the health of the Region's coastal wetlands.

The DRCWMP evolved from an initial concept and agreement in principle in 1999, to a detailed monitoring plan that was implemented in 2002 and has been carried out annually since implementation. This work has been a collaborative effort with the Central Lake Ontario Conservation Authority (CLOCA), including partners such as Environmental Canada (Canadian Wildlife Service), Toronto and Region Conservation Authority, Ganaraska Region Conservation Authority, volunteers and financial support provided by Durham Region and Ontario Power Generation.

The DRCWMP includes monitoring of the following biological and geophysical conditions annually in the marsh portion of the wetland:

- Biological
  - Submerged Aquatic Vegetation Community
  - Fish Community
  - Breeding Bird Community
  - Amphibian Community
  - Aquatic Macroinvertebrate Community
- Geophysical
  - Water Quality

- Sediment Quality
- Water Levels

In addition to annual monitoring, each wetland and the uplands within 500 m of the delineated wetland edge are assessed and mapped using the Ecological Land Classification (ELC) system (Lee et al. 1998). Data were also collected to assess sediment quality in 2002 and 2006. Eighteen wetlands throughout the Durham Region are now being monitored.

Since the project was initiated, there have been a number of documents written and published describing this project and its components. However, there has not yet been a report which highlights ecological conditions and trends guiding future management and restoration opportunities for each of the coastal wetlands. A report entitled DRCWMP: Conditions and Management Report, which includes all of these details, is now in progress. This report is divided into modules specific to each wetland and includes an introduction describing the information included in each wetland module. This presentation will discuss the content of this report and provides specific details for Bowmanville Marsh as an example.

### Methods

Each wetland module is divided into four sections: Attributes, Threats, Condition and Trends, and Management and Restoration.

*Attributes* – This section of each module describes the ecological attributes of the wetland. These include the wetland's size and location, hydrogeomorphology, vegetation communities, wildlife habitat structures and species at risk.

*Threats* – Factors which currently threaten the health of coastal wetlands include habitat loss, pollution, invasive species, water-level regulation,

shoreline modification, and recreation and cultural impacts. This section of each module describes the threats specific to each wetland.

*Conditions and Trends* – The conditions of the biological communities (submerged aquatic vegetation, fish, aquatic macroinvertebrates, amphibians, birds) and geophysical attributes (water quality, sediment quality and water levels) for each wetland were evaluated and quantified.

To report on the condition of biological communities Indices of Biotic Integrity (IBIs) are used. An IBI score (out of 100) is calculated for each biotic community for each wetland. The biotic community comprises: submerged aquatic vegetation (SAV); fish; aquatic macroinvertebrates; amphibians; and birds. Five IBI condition classes (Poor, Fair, Good, Very Good and Excellent) were identified according to ranges in IBI scores (EC and CLOCA 2009).

To report on the condition of water quality, the Water Quality Index (WQI) developed by Chow-Fraser (2006) was used. The WQI used for this project is based on four water quality variables: pH, conductivity, turbidity, and temperature. A WQI score ranging from -3 to +3 is calculated for each wetland and the dataset is divided into six condition classes (Highly Degraded, Very Degraded, Moderately Degraded, Good, Very Good, and Excellent).

The Sediment Quality Index (SQI) (Canadian Council of Ministers of the Environment 1999) was used to report on sediment quality. The SQI is calculated based on the number of Canadian Sediment Quality Guideline exceedances and the magnitude of those exceedances for a suite of contaminants of interest in the locality. The SQI is divided into six condition classes (Poor, Marginal, Fair, Good, and Excellent) ranging from 0 to 100.

The presence of barrier beaches causes many coastal wetlands to be disconnected from Lake Ontario for all or part of the year. Water levels are measured annually throughout the growing season (May through September) at eight marshes where dynamic barrier beaches are present.

To assess temporal trends in the IBIs and WQI for each Durham Region wetland, the Mann-Kendall trend test, a non-parametric correlational test, was performed.

*Management and Restoration* – The information presented in the preceding sections of the report sheds insight into the health of the wetlands and how they are changing, and highlights those threats which are having the greatest impact on each wetland. This knowledge provides guidance for future management and restoration options and opportunities.

Potential management and restoration options applicable to Durham Region coastal wetlands are grouped under general fields of science in this report: Hydrological, Chemical/Sedimentological, and Biological (Wilcox and Whillans 1999), as well as under a Recreational, Cultural and Social category. In the individual wetland modules, the suitable options for each wetland are listed and specific actions to achieve these options are recommended.

## **Results**

This report is currently in progress for several marshes. The following highlights the findings of the Bowmanville Marsh module.

### *Attributes*

- This is a 33-hectare drowned river-mouth coastal wetland located within the Bowmanville/Westside Marshes Conservation Area in the Municipality of Clarington.
- The wetland is a Mixed Shallow Aquatic community surrounded by Cattail Shallow Marsh. There is very little submerged aquatic vegetation and a low diversity of emergent vegetation.
- There are no wildlife habitat structures.
- Species at risk include:
  - snapping turtle (current records)
  - least bittern (last observed in 2002)
  - black tern (historical record in 1984)

*Threats*

- Pollution
  - The marsh faces a variety of stressors from both adjacent land use and from watershed land use changes upstream. Adjacent industrial, commercial and residential land uses directly contribute noise and light pollution to the marsh, while upstream land uses contribute to nutrient, thermal, and sediment pollution.
- Water-level regulation
  - The water level regulation of Lake Ontario prevents fluctuations in water levels necessary to keep vegetation communities regenerating and to maintain vegetation diversity (Maynard and Wilcox 1997). In Bowmanville Marsh this has led to large areas of open water with very little aquatic vegetation surrounded by a monoculture of Cattails.
- Invasive species
  - Common carp have aggressive feeding and spawning habits that cause sediments to be re-suspended and aquatic plants to be uprooted. European frog-bit reduces biodiversity by crowding out native vegetation and reducing light penetration thereby limiting growth of submerged plants.
- Shoreline Modification
  - The shoreline between Bowmanville Marsh and Lake Ontario has been significantly altered since the creation of the Port Darlington Harbour. A permanent boat channel connecting the creek and the lake provides access to the boat harbour. The channel prevents natural changes in barrier beach formation and requires frequent dredging to keep it open and accessible for boats. A lack of barrier beach formation prevents any possibility of water level fluctuation in the wetland beyond changes in Lake Ontario.
- Recreation and Cultural
  - Currently, boating, fishing, and encroachment have the most significant impact on this marsh. Boating can contribute to water quality impairment through the release of gas and oil into the water, motors stirring up sediment, and contributing to noise pollution with loud engines and the use of heavy equipment to move boats. Fishing activities on land have led to areas of trampled vegetation and have exacerbated existing bank erosion, where fisherman have created unsanctioned trails and fishing locations. Along the southern boundary of the marsh there has also been significant encroachment by adjacent landowners which disturbs wildlife and damages wetland habitat.
- Road Crossings
  - Automobile traffic poses a significant threat to wildlife that crosses the surrounding road to reach upland habitat or travel between this marsh and the nearby Westside Marsh. Turtles are particularly at risk as they are often found nesting along the gravel shoulder of the adjacent road. CLOCA has implemented turtle awareness and turtle nest protection program with area residents in an effort to reduce impacts on turtles.

*Condition and Trends*

- Water quality is improving; improved from Very Degraded to Moderately Degraded.
- Aquatic macroinvertebrate community is stable and in Fair to Good condition.
- Submerged aquatic vegetation community is in Poor condition with a low diversity and abundance of plants.
- Fish community is stable and in Fair to Good condition. Fish present are primarily tolerant species; the community is dominated by brown bullhead and has little trophic structure.
- Amphibian community is in Poor condition, with very low diversity and abundance of species.

## Monitoring and Research

- Bird community is declining. Overall in Fair condition with low diversity and few marsh-nesting obligate species.
- Sediment quality was Good and Excellent in the two years surveyed. A small number of sediment guideline exceedances were found upstream of the wetland for polycyclic aromatic hydrocarbons (PAHs), cadmium and DDT.
- Water level is the same as Lake Ontario with no variation due to lack of barrier beach formation and lake water-level regulation.

*Management and Restoration* – Table 1 in the Appendix is a list of the management and restoration options that are recommended for Bowmanville Marsh. Listed with each option are recommendations for specific actions that could be, or have been, implemented to aid in achieving these options. Also included in the table are the wetland conditions that are targeted for improvement, and the threats which may be mitigated through the implementation of each action.

## Conclusion

This project is necessary to evaluate the condition of coastal wetlands, observe changes in health over time and to use this information to provide recommendations for management and restoration. Making the connection between monitoring results and management recommendations is essential to ensure that we are not monitoring just for the sake of monitoring and that when changes are observed or threats identified we can focus our efforts to make improvements to wetland health. Informed management and restoration actions have a higher probability of success and ongoing monitoring allows for adaptive management.

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## Appendix

Table 1. Management and restoration options recommended for Bowmanville Marsh.

Management Type	Management Option	Management Actions	Target Conditions for Improvement	Threats Mitigated	
Hydrological	1	Restore natural variation of water levels to mimic pre-regulation Lake Ontario water level fluctuations.	Draw down wetland as required to mimic pre-regulation low water levels.	Water Quality Wildlife Communities Vegetation Communities	Water Level Regulation
	2	Restore or maintain wetland water table.	Maintain higher winter water levels to provide conditions suitable for muskrat houses.	Wildlife Communities	Water Level Regulation
Chemical and Sedimentological	1	Reduce inputs of sediment, nutrients, metals, organic pollutants, grease, oil and salt to the wetland.	Locate and eliminate illegal discharges in the watershed.  Promote best management practices in the watershed such as livestock fencing, tree planting and re-forestation, erosion control, bank stabilization, planting buffers, reducing road salt use, properly disposing of chemicals, minimizing fertilizer and pesticide use, implementing low impact development techniques, and rerouting drainage and discharge away from wetlands.	Water Quality Vegetation Communities Wildlife Communities	Pollution
	1	Manage invasive species.	European frog-bit: Map out current distribution of species population. Assess the feasibility of developing and implementing management plan to reduce or control this species.  Common carp: Install carp exclusion barrier to prevent adult carp from entering the marsh.	Wildlife Communities Vegetation Communities	Invasive Species
Biological	1	Manage invasive species.	European frog-bit: Map out current distribution of species population. Assess the feasibility of developing and implementing management plan to reduce or control this species.  Common carp: Install carp exclusion barrier to prevent adult carp from entering the marsh.	Wildlife Communities Vegetation Communities	Invasive Species
	2	Re-establish native plant species.	Draw down wetland as required to expose the seed bank and stimulate aquatic vegetation growth and diversity.	Wildlife Communities Vegetation Communities	Invasive Species

Management Type	Management Option	Management Actions	Target Conditions for Improvement	Threats Mitigated
3	Re-establish hemi-marsh conditions.	Draw down wetland as required to stimulate vegetation growth in open water areas.	Vegetation Communities Wildlife Communities Species at Risk	Water Level Regulation
4	Restore or improve bathymetry of wetland basin and shoreline to establish depth variation, create vegetation zones and improve wildlife habitat.	Create depth variation through the removal and re-distribution of sediment.	Wildlife Communities Vegetation Communities	Habitat loss
5	Add structure to provide habitat for fish and wildlife.	Install and secure turtle basking logs. Install osprey nesting platforms. Install underwater fish habitat structures. Install duck nest boxes.	Wildlife Communities	Habitat loss
6	Restore or enhance wetland buffers.	Establish plantings of native species and install fencing to prevent adjacent lakefront landowners from encroaching into wetland.	Water Quality Wildlife Communities Vegetation Communities	Pollution
7	Isolate wetland or portion(s) of to allow for water drawdowns and carp exclusion.	Install berm and control structure across the mouth of Bowmanville Marsh.	Water Quality Wildlife Communities Vegetation Communities	Water level Regulation

Management Type	Management Option	Management Actions	Target Conditions for Improvement	Threats Mitigated
Recreational, Cultural and Social	1	<p>Improve public education and awareness of wetland features and functions.</p> <p>Increase signage to keep users on designated trails, educate them about Bowmanville Marsh, and inform them of ways they can reduce their impact on the marsh.</p> <p>Incorporate a kiosk and lookout at the berm location that includes wetland information, various opportunities and tools to report species sightings, and contact information for CLOCA staff.</p> <p>Develop a birding checklist for Bowmanville Marsh which incorporates a map of appropriate viewing locations and provides rarity information for each species.</p>	<p>Wildlife Communities</p> <p>Vegetation Communities</p>	<p>Recreation and Cultural Impacts</p>
	2	<p>Promote stewardship of wetland.</p> <p>Encourage users to report species at risk sightings to the Natural Heritage Information Centre and CLOCA.</p> <p>Encourage involvement of various user groups to report wildlife activity, take and submit photographs, and provide local knowledge of wetland health.</p> <p>Continue to provide turtle nest protection structures and training to volunteers interested in actively protecting nesting sites.</p> <p>Encourage users to adopt best visitor practices at site (i.e. keeping to designated trails, packing out garbage, etc.).</p> <p>Reduce and minimize encroachment impacts by enhancing buffers and installing vegetation barriers, as well as by educating and involving adjacent landowners.</p> <p>Create designated fishing locations to reduce impacts of vegetation trampling and erosion along creek and wetland banks.</p>	<p>Wildlife Communities</p> <p>Vegetation Communities</p>	<p>Recreation and Cultural Impacts</p> <p>Pollution</p>

Management Type	Management Option	Management Actions	Target Conditions for Improvement	Threats Mitigated
		Continue to monitor the wetland through the DRCWMP, and use this data to inform future management decisions and educate the public on the importance and function of coastal wetlands.		
3	Reduce mortality of wildlife caused by automobiles.	<p>Install signage in high crossing areas.</p> <p>Install speed-calming structures in high crossing areas.</p> <p>Reduce speed limit on West Beach Road.</p> <p>When road upgrades are necessary, promote the installation of wildlife passages to allow wildlife to cross underneath West Beach Road. Install exclusion fencing to prevent wildlife from crossing road and direct them to wildlife crossings.</p>	Wildlife Communities Species at Risk	Road Crossings

## Water Level Regulation in the Great Lakes: Adaptive Management Monitoring of Habitat in Lake Ontario Coastal Wetlands

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### Introduction

Coastal wetlands are some of the most diverse and imperiled systems in the Great Lakes (Environment Canada 2002). Coastal wetlands hold great societal and ecological value by providing key ecosystem services such as habitat for a variety of wildlife, shoreline stabilization, nutrient sequestration and cycling, and aesthetic value (Environment Canada 2002). One of the main driving forces affecting wetlands along large lakes is hydrological variation of lake water levels (Simon and Stewart 2006). As a result, the types and abundances of wetland vegetation change in response to the water level regime (Keddy and Reznicek 1986). Water level regulation in the Great Lakes basin is a balancing act among a number of competing interests such as commercial navigation, industry, shoreline landowners, hydropower generation, recreational boating, and the environment, including coastal wetlands. Regulating water levels is implemented by controlling flow rates through dams to modify water levels. Two major dams exist in the Great Lakes, one in Sault St. Marie (Soo Locks) at the outflow of Lake Superior, and the other at Cornwall, Ontario (Moses Saunders Dam) in the St. Lawrence River at the outflow of Lake Ontario.

Water level fluctuations, especially the extreme highs and lows, are essential for maintaining diversity in coastal wetlands (Keddy and Reznicek 1986, Wilcox and Nichols 2008). In Lake Ontario, water levels have been regulated for over 50 years, which reduces the total area that experiences a flooding and dewatering cycle (Wilcox et al. 2005). In 2000, the International Joint Commission (IJC) issued a directive to the International Lake Ontario-St. Lawrence River Study Board (ILOSLSRB) to conduct a five-year water-level regulation review study. The objective of the study was to develop a revised regulation

plan by evaluating the performance of candidate plans at providing a better balance among all interests in the region (ILOSLSRB 2006). This included modeling coastal wetland plant dynamics under a variety of regulation scenarios. The final report outlining potential options for managing Lake Ontario and St. Lawrence River water levels and flows was completed in March 2006.

Water level regulation in Lake Ontario is managed using an adaptive management approach in which the latest available science and data are used to continually evaluate and adjust the management of the system (ILOSLSRB 2006). Monitoring is a large component of this approach, as field-collected data can be used to validate ecosystem modeling and provide feedback on the outcomes and success of particular management actions. Environment Canada – Canadian Wildlife Service (EC-CWS) conducts monitoring of wildlife habitat in Lake Ontario coastal wetlands. The data can be used in the adaptive management process to help determine if expected wetland improvements are realized and to support modeling the effects of alternative approaches to water-level management. The main objectives of this habitat monitoring project are to: 1) provide baseline data on the elevations occupied by coastal wetland vegetation communities, 2) determine the local water level conditions at a variety of wetland types (barrier protected, embayment, drowned river mouth), 3) determine the relationships between water levels and vegetation, and 4) develop spatial products (e.g. bathymetry) that can aid in the modeling of future changes in the vegetation community. This paper outlines the monitoring framework that has been employed in Lake Ontario and the variety of methods used to collect these data.

## Methods

This monitoring project includes a number of complex analytical and operational techniques. This extended abstract provides basic methodological information, but does not include detailed descriptions of these components. Great Lakes water levels and water-level products (e.g. bathymetry and habitat modeling) are measured using the International Great Lakes Datum referenced to 1985 (IGLD85). In addition, the International Joint Commission Control Board expresses water management levels in reference to IGLD85. Vertical control or benchmarks are not readily available in the coastal zone of the Great Lakes for use near wetlands. The tools to derive these data in the target datum are complex and typically beyond the expertise of wetland ecologists. From multiple iterations using a variety of technologies, it was determined that global positioning systems (GPS) technologies are suitable to establish vertical control (i.e. benchmark) and be used for relative positioning using real-time kinematic (RTK) – GPS surveys of habitat.

GPS data are collected in the World Geodetic System 1984 (WGS84), not IGLD85, and these two systems do not have the same origin, nor do they use the same geoid for modeling the earth's surface. It was important to convert elevation values to IGLD85 standards for this study to allow for direct comparisons. The monitoring framework for this study requires that observers vertically reference data during vegetation surveys, water level surveys, or hydrographic surveys in real-time by targeting specific elevations and/or specific habitat types or water levels. By using survey-grade GPS technology and techniques, these objectives are able to be met.

Establishing vertical control is completed by collecting raw GPS data in WGS84 using a survey-grade receiver (Trimble R8GNSS Model 3, Sunnyvale, CA, USA) for four to 24 hours uninterrupted at a stable location. Data are uploaded to a free online post-processing system maintained by Natural Resources Canada (NRCAN) Geodetic Survey Division (NRCAN 2013a) which

uses precise satellite orbit and clock data to produce a coordinate solution in three dimensions. This technique is called Precise Point Positioning (PPP; Mireault et al. 2008) and the resulting accuracy of the data collected over long observation periods is typically within a centimetre both horizontally and vertically (NRCAN 2007, NRCAN 2013b). Generally, longer GPS observation periods result in higher accuracy and precision of the resulting post-processed data. PPP processing output provides height values using the Canadian Geodetic Vertical Datum, CGVD28, and now updated to CGVD2013. To use these data in the coastal zone of Lake Ontario, however requires converting them to IGLD85. Local shifts were computed using regional monument data supplied by NRCAN. The mean separation between the CGVD28 and IGLD85 heights for the nearest monuments were applied to the created benchmarks (EC-CWS unpublished data). From 2008-2009, 14 elevation benchmarks were created using this technique along the north shore of Lake Ontario (Fig. 1). Benchmark accuracies were within 1-2 cm in IGLD85 (EC-CWS unpublished data).

Relative positioning using a benchmark as a reference point was conducted using RTK-GPS. The RTK-GPS system was set up with a base station and two roving units. The base station was located over a created benchmark with a known elevation. The roving units were used by two sampling teams to locate the correct elevation to sample vegetation. The roving units and base station communicate wirelessly and can communicate at distances of up to 10 km and provide GIS-enabled data at a very high horizontal and vertical accuracy. *Vegetation Surveys* – Vegetation surveys were conducted to characterize plant zonation at 15 study sites. Site selection was based on regional representativeness, existence of multiple vegetation types, distribution, access, hydrogeomorphic type (e.g. barrier protected, embayment, drowned river mouth), and covariate data (e.g. water quality, biotic communities). Sampling occurred in late August/early September during maximum vegetative growth to determine

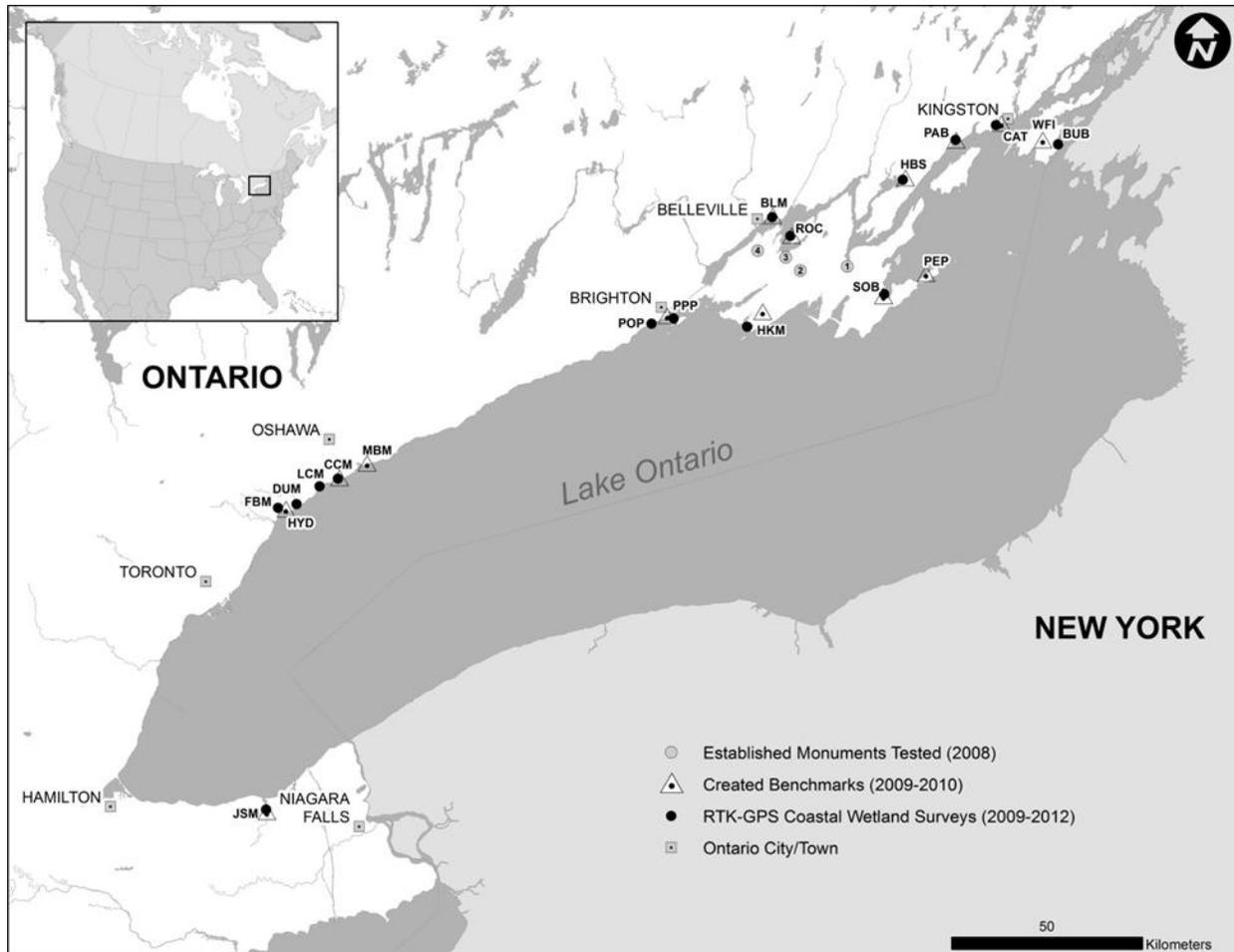


Figure 1. Elevation benchmarks and vegetation survey locations along the north shore of Lake Ontario, Canada.

the complete extent of the marsh. Vegetation was sampled along elevation transects from 74.0-76.0 m IGLD85 which corresponds from roughly a 1 m water depth to the marsh-upland boundary (Fig. 2). RTK-GPS was used to target 20 cm elevation increments within this 2 m elevation range to standardize the sampling among sites. This resulted in 11 sample stations along a single transect (Fig. 2), and 12 transects were sampled at each wetland. At each sample station, total cover and individual species coverage were recorded by surveyors within a 0.5 m x 1 m quadrat with the short edge of the quadrat along the elevation gradient. Not all elevations could be sampled at both the low elevations (74.0 m and 74.2 m) due to shallow basin morphometry; and at the higher elevations (75.6 m, 75.8 m, and 76.0 m) due to established shrub canopy cover the interfered with GPS reception. In addition, 20 cm elevation

increments were used as they work well with identifying plant zonation, can be accurately targeted with RTK-GPS equipment, and provide a good balance between field productivity and data resolution.

To investigate vegetation zonation, and for data analysis, species data were categorized into five vegetation communities: 1) submerged aquatic vegetation (SAV); 2) non-persistent emergent; 3) cattail (persistent emergent); 4) meadow marsh; and 5) shrub, which reflect the major guilds present in coastal marshes. SAV encompassed all submerged and rooted floating species and non-persistent emergent include species that grow through the water column annually such as pickerelweed, bur-reed species, and arrowhead species.

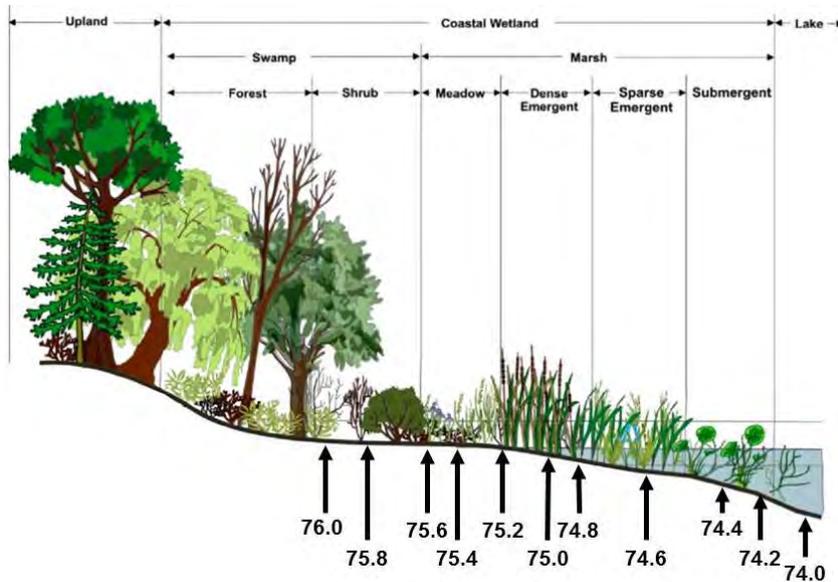


Figure 2. Typical zonation of wetland vegetation across an elevation gradient (74.0-76.0 m IGLD85) from open water (R) to upland forest (L) in a lacustrine system.

**Measuring Local Water Levels** – Water levels were recorded at 15-minute intervals during the growing season (late April to early November) simultaneously at a number of wetlands in Lake Ontario. A water level logger (Levellogger: Model 3001, Solinst, Georgetown, ON, Canada) and a barometric pressure logger (Barologger: Model 3001, Solinst, Georgetown, ON, Canada) were deployed in each wetland. The water level loggers were housed in ABS piping fastened to a square piece of sheet metal and placed on the wetland sediment as deep as safely wadeable which ensured that they were not exposed to air during seasonal lows and seiche effects. The sheet metal base was necessary to ensure the logger housing remained in a fixed position for the duration of the deployment (Fig. 3A). Water level loggers measure the pressure above an internal sensor that is a combination of the pressure from standing water and the air pressure above the water. Barologgers were used to correct for the effect of air pressure and were typically secured to a tree close to the shoreline. A single barologger could be used to compensate multiple water level loggers within a 30 km radius (Solinst 2012). Both the water level and barometric pressure logger deployment locations were recorded to the nearest metre with a handheld GPS unit (Trimble GeoXT, Sunnyvale, CA, USA).

Data from the water level loggers are relative, and so RTK-GPS measurements were recorded at the water level during vegetation surveys to correct the data to IGLD85.

**Results**

Thirty-four wetland-years of data from 2009-2013 were used to generate plant guild abundance ranges along elevation gradients in Lake Ontario coastal marshes (Fig. 4). These data are presented as the mean cumulative percent cover at each elevation for each vegetation guild. Cumulative coverage within a quadrat can exceed

100% due to vertical stratification of vegetation within the two dimensional sampling plane of the quadrat (Fig. 4). Plant guild abundances typically follow a polynomial relationship with elevation and different plant guilds can occupy the same elevation but with different abundances. SAV does not appear to follow a polynomial relationship with elevation; however the lowest elevation surveyed (74.0 m) was well above the lower limit of SAV growth in coastal wetlands. Non-persistent emergents and cattail do not exhibit high abundances in these data.

Site-level water level data were collected at high precision and accuracy for an extended period of time at a number of sites simultaneously. An example of a wetland hydrograph is presented in Figure 3B. Mean daily values are plotted and a daily subset is included to illustrate that fine scale fluctuations can be captured using this technique. Although not presented here, no substantial changes were observed in the relationships between elevation and vegetation cover of the different guilds between 2009 and 2013 at specific sites, and during this time water levels did not follow a defined trend (e.g. sustained high or sustained low) but were variable (EC-CWS unpublished data).

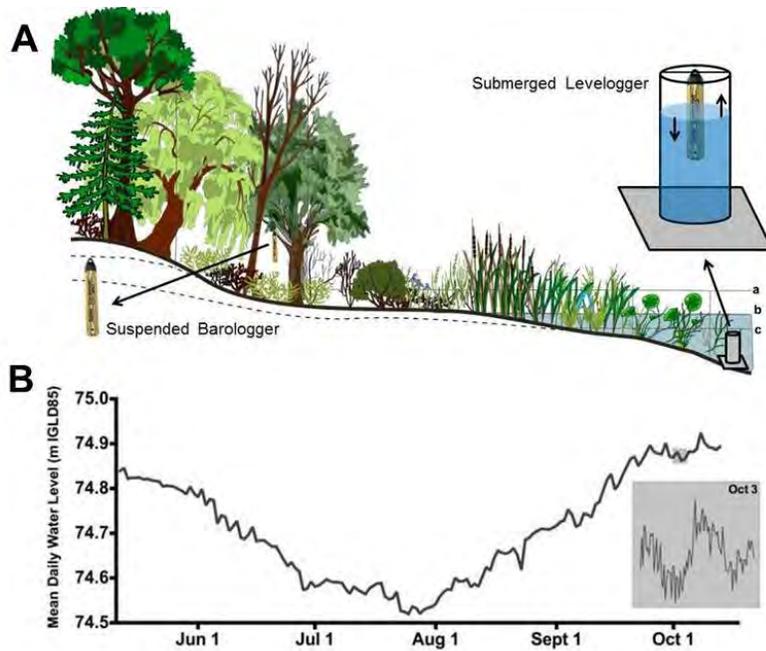


Figure 3. Site-specific water level data collection using portable dataloggers (A) and an example of mean daily and hourly (inset) water levels from South Bay Marsh in 2010 (B).

## Discussion

Variation exists in the relationship between elevation and abundance of vegetation guilds, which we infer is the result of a host of local factors such as level of disturbance, presence of invasive species, exposure, vegetation lag time to change, and local water level history. Further study of this zonation by separating the data by hydrogeomorphic type will help to provide a better resolution of how each wetland type could be impacted by changes in the water level plan. Greater sample sizes are necessary to encompass the full range of conditions (e.g. high quality and poor quality) for each hydrogeomorphic type which will allow us to meet this objective. Ongoing field data collection will reflect the need to expand our surveying.

The fact that plant guilds typically follow polynomial relationships with elevation and that guild distributions overlap but dominate different elevations provides quantitative data of plant zonation in coastal marshes. This study is unique in Lake Ontario because it is the first we know of to quantitatively illustrate the fundamental zonation of vegetation communities (habitat) in

wetlands with this level of precision. It is interesting that not all guilds peak at similar abundance levels but it follows what is typically observed in these sites. Non-persistent emergents and cattails do not exist at high abundances due to their life history traits and growth forms. Non-persistent emergents grow through the water column and so they are susceptible to impacts from impaired water quality from anthropogenic disturbance. Therefore, when the data were compiled from a number of sites in varying levels of condition, impacted sites have few, if any, of this guild, which lowered the average abundance at each elevation. Although cattails do not exist at high abundances, they dominate wetlands from 74.8-75.2 m in elevation. The cattail growth

form is tall and slender and typically exists with a considerable layer of persistent senescent material at the substrate which provides positive feedback for continued dominance with each year's cycle of senescence and regrowth.

Nutrient enrichment and sedimentation can lead to changes in species composition favouring species tolerant of these conditions including invasive species. Further investigation into the effects of disturbance and invasive taxa on plant zonation is necessary as these can be major

driving forces in the Lake Ontario basin and can have a large influence on the vegetation observed in a wetland. Lack of extreme highs and lows in water levels and succession may also facilitate the expansion of invasive species such as *Typha X glauca* into the ranges of other guilds such as meadow marsh and non-persistent emergents and so it is possible that this project will be able to track this expansion over time.

Continued monitoring under a variety of water-level conditions will provide the spatial and temporal changes in wetland vegetation in

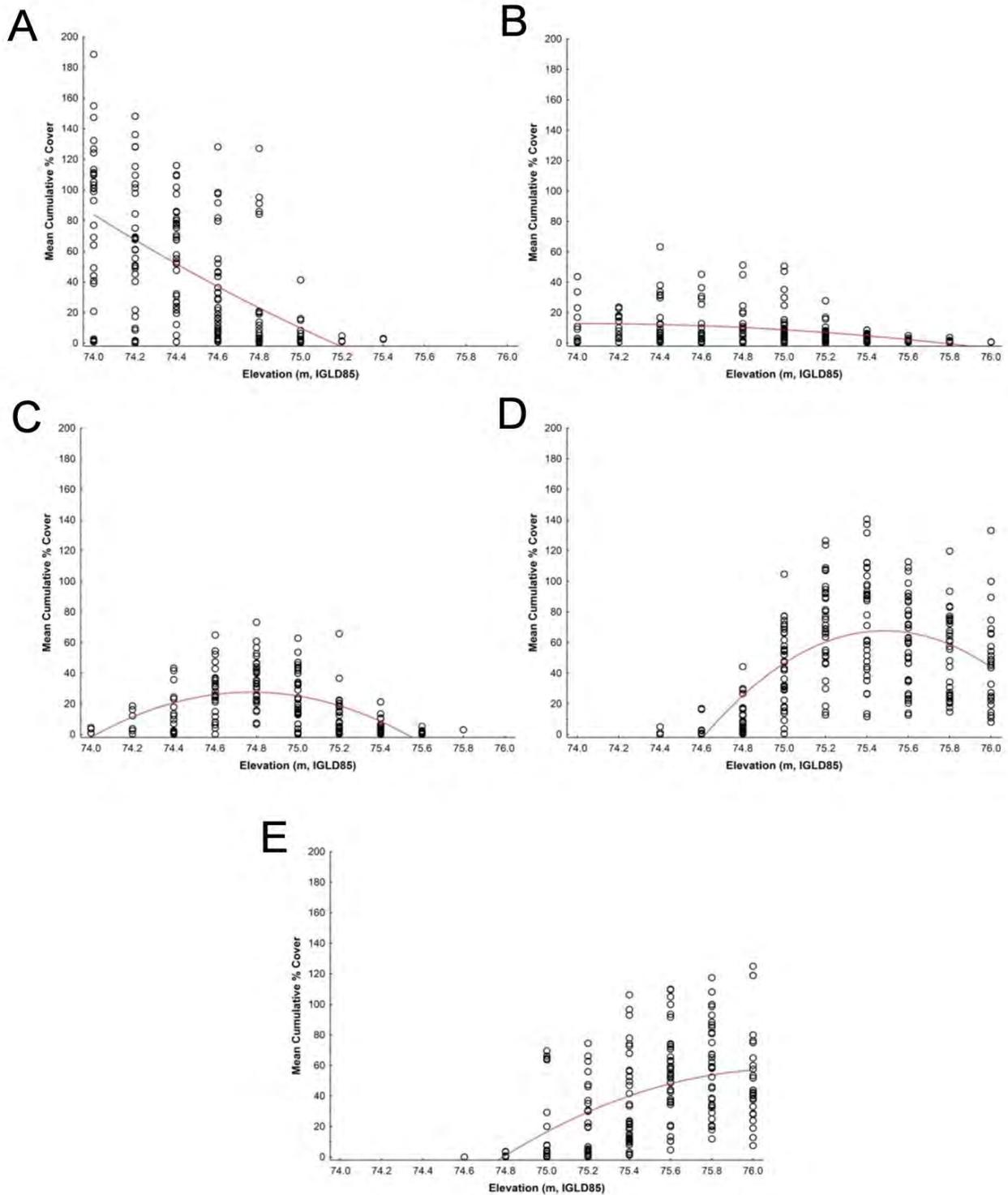


Figure 4. Mean cumulative percent cover of five vegetation guilds (submerged aquatic vegetation [A], non-persistent emergent [B], cattail [C], meadow marsh [D], and shrub [E]) with respect to elevation in Lake Ontario coastal marshes from 2009-2013.

response to water levels. Currently no decision has been made to alter the regulation of Lake Ontario; however should a change be made, this project will provide greatly needed insight into the potential changes in coastal wetland vegetation and will help to determine how these changes will impact a variety of wildlife communities.

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## Delisting Frameworks for Great Lakes Areas of Concern

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### Introduction

In 1985, the International Joint Commission identified Areas of Concern (AOCs) in the Great Lakes. There were 12 AOCs identified in Canada and an additional five binational AOCs that spanned Canada-United States connecting channels (e.g. Detroit River). Following remedial efforts, three of these areas have been delisted and another one is listed as an Area in Recovery. Great Lakes AOCs were designated as such because they were locations where environmental quality had been obviously degraded. Environmental degradations were termed Beneficial Use Impairments (BUIs; Table 1). Beneficial Use Impairments most applicable to coastal wetlands in AOCs are Degradation of Fish and Wildlife Populations and Loss of Fish and Wildlife Habitat (BUIs 3 and 14, respectively). There are several elements of wetland condition considered within these BUIs. Relevant elements of coastal wetland fish and wildlife population include the condition of marsh bird, anuran (frog and toad), and fish communities. Water quality and the condition of submerged aquatic vegetation and aquatic macroinvertebrate communities are used (the latter seemingly more wildlife-related, but used instead as a proxy for antecedent water quality) to assess fish and wildlife habitat impairments. A monitoring framework used to collect field data for fish and wildlife communities in AOCs has long been established through partnered multidisciplinary coastal wetland assessments in the Great Lakes including the Durham Region Coastal Wetland Monitoring Project and Environment Canada's Coastal Habitat Assessment and Monitoring Project. Data for marsh bird, fish, anuran, submerged aquatic vegetation, and aquatic macroinvertebrate communities are expressed separately as indices of biotic integrity (IBIs) while water quality is reported using a water quality index (WQI). The IBIs are expressed as a number

between 0 and 100, with higher numbers representing sites with higher biotic integrity. The WQI is conveyed on a scale ranging from -3 to +3 again with higher numbers indicating better water quality. While these indices provide an indication of the condition of fish and wildlife populations and habitats within selected AOCs, the question remains – What IBI or WQI threshold represents and non-impaired system? For example, should the average submerged aquatic vegetation IBI in coastal wetlands within an AOC be 70 (out of 100) to be considered not impaired? Why? The remainder of this paper briefly describes field methodologies, then offers paradigms for delisting thresholds (impaired or not-impaired?), and explores a specific example in the Bay of Quinte AOC.

### Methods

As part regional AOC assessments, selected coastal wetlands were monitored focusing on two components: 1) abiotic condition, measured using

Table 1. List of possible Beneficial Use Impairments in Great Lakes Areas of Concern.

Impaired Beneficial Use	
1	Restrictions on fish and wildlife consumption
2	Tainting of fish and wildlife flavour
3	Degradation of fish and wildlife populations
4	Fish tumours and other deformities
5	Bird or animal deformities or reproduction problems
6	Degradation of benthos
7	Restrictions on dredging activities
8	Eutrophication or undesirable algae
9	Restrictions on drinking water or taste and odour problems
10	Beach closures
11	Degradation of aesthetics
12	Added costs to agriculture or industry
13	Degradation of phytoplankton and zooplankton populations
14	Loss of fish and wildlife habitat

water quality and 2) biological condition, measured using IBIs from marsh bird, anuran, fish, aquatic macroinvertebrate, and submerged vegetation community surveys.

*Water Quality* – The water quality parameters of temperature, conductivity, turbidity and pH were measured throughout the wetland. These parameters are used to calculate a version of Chow-Fraser's (2006) Water Quality Index.

*Marsh birds* – Surveys were conducted from May to July and consisted of three different visits to point count stations throughout the wetland. Breeding marsh bird communities are surveyed using a modified Marsh Monitoring Program (MMP) protocol (Meyer et al. 2006) to report on site-level or specific AOC wetland bird communities.

*Anurans* – Frogs and toads were surveyed at point count stations throughout the wetland from April unto early July. Stations were visited during three replicate visits and followed the Marsh Monitoring Program protocol.

*Aquatic macroinvertebrates* – Three replicate subsamples of approximately 150 nektonic and epiphytic aquatic macroinvertebrates ( $\geq 500 \mu\text{m}$ ) were taken by sweep-netting through the water column in the cattail-dominated or flooded common reed emergent communities based on Burton et al. (2008). Macroinvertebrates were sampled in July/August, during the time when most invertebrates were present as mid- to late-instars and then identified to the lowest taxonomic group possible.

*Submerged vegetation* – Total areal coverage and species-specific coverage for submerged and floating-leaved species were recorded in one-metre square quadrats at 20 random locations in the open water basin of each wetland (Grabas et al. 2012).

*Fish* – Fish communities were surveyed by electrofishing along 44-metre transects stratified by habitat type. Individuals were identified to species, weighed, and the fork length was measured.

*Index of Biotic Integrity Development* – To assess the biological condition of coastal wetlands, IBIs were developed separately for each biological community (marsh birds, invertebrates, fish, and SAV) using a multimetric approach. Community metrics (e.g. species richness) were tested against disturbance and the metrics shown to respond significantly to disturbance were then used to develop an IBI (e.g. Grabas et al. 2012). Because the disturbance gradient and taxa assemblage are regionally specific, so are the resulting IBIs. IBIs can range from 0 to 100 and help classify communities as poor (0 – 20), fair (20 – 40), good (40 – 60), very good (60 – 80), and excellent (80 – 100; EC and CLOCA 2004). While the IBI has a strong biological underpinning, the overall score between 0 and 100 allows non-experts to easily and intuitively understand the results.

Environment Canada – Canadian Wildlife Service – has used IBIs in the wildlife population and habitat-related delisting criteria development process in the St. Marys River, Bay of Quinte, Wheatley Harbour, St. Clair River, and Detroit River AOCs.

Using indices, Macecek and Grabas (2011) suggest three potential paradigms for delisting wildlife communities and habitat. Refinements to these paradigms have occurred and are recast below.

*Comparison against a static benchmark based on recent data* – In this case, for example, a decision has been made by the Remedial Action Plan Council (or equivalent) that because of AOC-wide remedial actions, maintenance of current conditions (static benchmark) would be sufficient for delisting. That is, the average index across AOC sites or, more realistically, a subset of sites should remain at or above the static benchmark to be considered not impaired (Fig. 1A; the horizontal line at 60 indicates the static benchmark). This could be done when exact past conditions were not known but there is substantial observational and circumstantial evidence to suggest that there have been recent gains in AOC condition. Alternatively the static benchmark can be developed using selected sites outside of the AOC.

*Comparisons against a dynamic benchmark* – Here, two suites of wetlands are used: a set of wetlands inside the AOC and a set outside. The overall condition (e.g. mean marsh bird community index) of the set of sites outside the AOC is used as a dynamic benchmark (Fig. 1B). For the element of the BUI to be considered not impaired, the conditions within the AOC should be at or above the sites outside of the AOC. Sites outside of the AOC should be chosen to be representative of conditions across the same geophysical setting (i.e. include a range of good and poor sites in the same lake or connecting channel). The advantage to this approach is that it can account for broader-scale influences on or within the AOC. For example, if a change in Lake Ontario water-level regulation resulted in better habitat for breeding marsh bird communities across Lake Ontario, it is expected these improvements would be realized in the Bay of Quinte AOC. If the improvements did not occur, it may signal that the magnitude of an AOC-specific stressor was increasing. Conversely, if lake-wide wetland conditions decreased due, for example, to climate change impacts, the decrease in AOC condition may not result in ‘re-listing’ of the impairment because the stressor would not be AOC-specific.

*Set targets based on expert opinion* – In some AOCs, there are few, if any, recent or historical data. For other AOCs (e.g. Detroit River), there are no comparable (i.e. riverine) sites outside of the AOC – the AOC is comprised of the entire river, and the neighbouring St. Clair River is also an AOC. In this case, practitioners might consider developing delisting criteria based on expert opinion of a less environmentally impacted area. Targets can be set as an overall IBI score (e.g. submerged vegetation IBI of 70 is considered ‘not impaired’), but it would be more practical to set the target based on the constituent metrics of the IBI. For example, the submerged vegetation IBI incorporates metrics such as overall coverage and native species richness. Using expert opinion or experience/data from other Great Lakes coastal wetlands, decisions can be made for what level of overall submerged vegetation coverage, native

species richness, etc., would be sufficient to consider the submerged vegetation community ‘not-impaired’. The metric values defined by expert opinion would be combined, just as field data are combined, to create an IBI-value. This IBI-value would represent benchmark where the community condition (or mean community condition across a suite of sites) in the AOC would be considered ‘not-impaired’ (Fig. 1C the horizontal line at 80 indicates the benchmark). In the example shown, the delisting criterion benchmark was set quite high (possibly unrealistically so) and conditions have just reached ‘not-impaired’.

Ultimately, wetland stakeholders, conservation agencies, and the respective Remedial Action Plan Councils should be instrumental in choosing a model and developing and approving the delisting criteria. A blended approach based on models described above can be used in AOC, as well. A practical example of a blended model for delisting is detailed below.

## Results

The example below shows an example of a delisting criterion currently used in the Bay of Quinte AOC where the submerged vegetation community is considered an element of the BUI 14 – Loss of Fish and Wildlife Habitat. The delisting model used in this case is a blend of model 1 and 2 described above. It was decided that a static benchmark based on recent conditions with the AOC would be used. However, changing conditions outside the AOC are to be used to adjust the benchmark. The delisting criterion for submerged vegetation in the Bay of Quinte was stated as:

The submerged aquatic vegetation community IBI at representative Bay of Quinte coastal wetlands shall not be *more than two standard deviations*<sup>2</sup> below the *2006-2010 representative site mean*<sup>1</sup> that accounts for varying conditions in Lake Ontario *outside of the AOC*<sup>3</sup> from 2006-2010.

<sup>1</sup>Because not all coastal wetlands can be monitored in the Bay of Quinte AOC, ten representative sites have been established (Environment Canada 2007). A recent mean

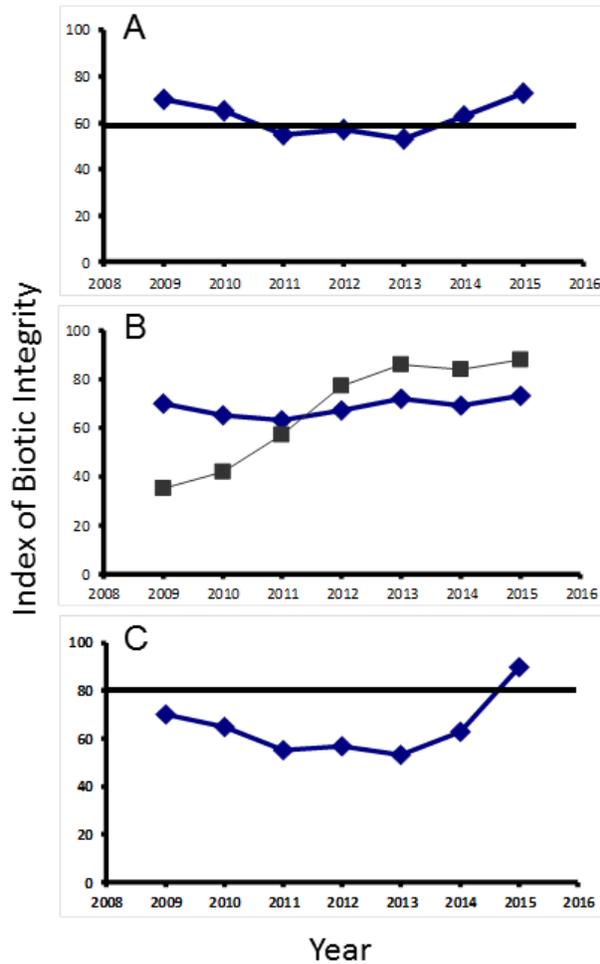


Figure 1. Depiction of three possible Great Lakes Area of Concern delisting models for wildlife and habitat-related Beneficial Use Impairments that incorporate the use and reporting of indices.

(2006-2010) submerged aquatic vegetation index of biotic integrity (SAV IBI) was calculated to summarize current conditions in the AOC. Recent conditions were used because the general sentiment among biologist with experience in numerous Lake Ontario coastal wetlands was: Conditions within the Bay of Quinte are some of the best in Lake Ontario. If these conditions can be maintained, that should be sufficient to be considered not impaired. The mean, (called the benchmark mean) is 78.6. Future mean IBIs for these sites should be 78.6 or higher (but see 2 below).

<sup>2</sup>Although the benchmark mean is 78.6, it is recognized that there is natural variability within

these communities that translates into natural variability in the IBI. Therefore, the condition of the SAV community should be able to be lower than 78.6, but still within the natural variability. Natural variability of the mean is defined as two standard deviations. The standard deviation about the benchmark mean is 8.0. So the representative site mean can go as low as  $78.6 - 8.0 \times 2 = 62.6$  and still be considered as not impaired. Therefore, the lower limit to be considered not impaired is 62.6.

<sup>3</sup>It is also recognized that there could be large scale phenomena (e.g. climate change) affecting the Lake Ontario basin. For example, if the representative site mean plunges below the lower limit (62.6), then the SAV community should be considered impaired. But if the decrease in the SAV community condition is not due to a disturbance (i.e. decrease in physical, biological or chemical integrity) that is Bay-of-Quinte-specific and is affecting all of Lake Ontario, then the lower limit should be lowered accordingly. The converse is true – if lake-wide conditions increase with a resulting increase in SAV IBI at sites outside of the Bay of Quinte AOC, the lower limit should be increased accordingly.

There is also recognition that phenomena affecting sampled sites within Lake Ontario may not necessarily affect the Bay of Quinte and the lower limit *should not* be adjusted accordingly (e.g. invasive species establishment in Lake Ontario outside of the Bay of Quinte). If this were to occur, it would be the responsibility of the reporting agency to decide whether and how to adjust the lower limit.

**Summary: Determining the Status of Loss of Fish and Wildlife Habitat (sub-criterion 2; submerged vegetation community) in 2012**

Target: Submerged aquatic vegetation in Bay of Quinte coastal wetlands is not impaired

- From above, benchmark mean is 78.6. With the standard deviation adjustment (for natural variability) the benchmark mean is lowered to  $78.6 - 8.0 \times 2 = 62.6$ .
- The mean SAV IBI outside of the Bay of Quinte in 2012 was 31.4 and in 2006-2010

was 22.1 (data were collected through various agencies for primary use in other programs). The 2012 IBI has an increase of  $31.4 - 22.1 = 9.3$  IBI points over the 2006-2010 IBI outside of the Bay of Quinte. Therefore, in 2012, the lower limit should be adjusted to  $62.6 + 9.3 = 71.9$ .

- To be considered not impaired, the mean for 2012 representative sites (from field data collection) must be above 71.9. The mean SAV IBI for 2012 representative sites was 83.3, therefore SAV community in the Bay of Quinte is considered not impaired in 2012.
- The representative site mean for 2009 was 88.5 and therefore in 2009 FWH-2 is *not impaired*.

### Discussion

This paper outlines some delisting paradigms for fish- and wildlife-related beneficial use impairments in Great Lakes AOCs. The blended model shown above has been used for years in the Bay of Quinte AOC for fish, birds, anurans, submerged aquatic vegetation, and water quality. This discussion will touch on some of the key considerations for using IBIs in delisting models.

It is important to note that IBIs should be developed and used regionally. Stressors and species assemblages vary across Great Lakes AOC (e.g. St. Clair River vs. St. Marys River). For example, an IBI for vegetation in the St. Clair AOC may incorporate the presence/absence of American lotus (*Nelumbo lutea*) in its species richness metric. This metric (and resulting IBI) would not be suitable in the St. Marys River because this location is beyond the natural range of American lotus. Additionally, although the submerged vegetation IBI developed for Lake Ontario has been shown to work in Lake Erie (Grabas et al. 2012), it does not work well in the St. Clair or Detroit AOC despite having near-identical species assemblages. It is thought that the stressors in the riverine systems may act differently on the submerged vegetation community than in a lacustrine setting.

The effective use of the delisting models described in this paper requires wetland

assessments. Field and data treatment methodologies have been developed and in use for several years. Securing resources for wetland assessment and monitoring can be difficult, but there are some recent and ongoing efforts in the Great Lakes that generate data suitable on incorporation into the delisting models described in this paper. In the lower Great Lakes, Durham Region Coastal Wetland Monitoring Project partners collect data integral for Bay of Quinte AOC comparisons. Through the Government of Canada's Great Lakes Action Plan, numerous AOC coastal wetlands are assessed annually. The Canadian Wildlife Service also monitors wetlands across the lower Great Lakes through the Coastal Habitat Assessment and Monitoring Program. Finally, the coastal wetland monitoring component of the USEPA-funded Great Lakes Restoration Initiative will continue assessments of hundreds of coastal wetlands across United States and Canadian from 2011 to 2015. Data generated through these projects can help support delisting criteria development, refinement, and reporting in Great Lakes AOCs. Although these projects collect a common suite of wetland variables (birds, anurans, fish, vegetation, aquatic macroinvertebrates, and water quality), additional assessments on other wetland biota could also be incorporated into delisting models (e.g. turtles, muskrats).

Whether data collected through these projects are gathered for the express purpose of supporting delisting criteria reporting (e.g. Great Lakes Action Plan) or for other purposes, all these data help support non-AOC wetland conservation efforts such as identification of biodiversity hotspots and priority locations for restoration. Delisting models can be equally useful in non-AOC restoration projects where wetland managers and practitioners need to define, monitor, and report on restoration targets and ecological endpoints.

Finally, to support effective and robust wildlife and habitat delisting criterion reporting, ongoing wetland monitoring in AOCs and across the Great Lakes basin is essential. Area of Concern practitioners have expressed the need for 'eternal vigilance' following BUI delisting, with monitoring

being the key, to ensure that beneficial uses do not slip back into an impaired state.

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## Investigating the Carbon Storage and Accumulation Rates of Wetlands within the Agricultural Landscape of Southern Ontario

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### Introduction

Canada is the fourth-largest exporter of agriculture and agri-food products in the world with exports valued at \$28 billion, but instability of agriculture markets can make it difficult for farmers to cope with variability and new mechanisms are needed for farmers to achieve economic stability. There is increasing pressure from consumers for products that are produced using environmentally sustainable practices. Capitalizing on carbon markets will help farmers achieve environmentally sustainable economic performance to meet or exceed society's expectations. In order to have a viable carbon market, governments and industries need to know what the carbon capital is and what potential there is for growth, and farmers need financial incentives that will allow farmers to not only conserve existing wetlands but that will also enable them to restore wetlands while making a living.

In southern Ontario, a farmer's need to maximize the return on his/her investment on marginal lands has resulted in significant loss of wetlands, making this region one of the most threatened regions in terms of wetland degradation and loss in Canada.

This project seeks to establish the role that mineral wetlands have in the net carbon balance by contributing invaluable insight into the potential benefits to carbon management provided by wetland restoration efforts in these highly degraded landscapes. The project has three objectives: (1) estimate the magnitude of wetland loss in southern Ontario; (2) estimate carbon sequestration rates in natural, degraded and restored mineral wetlands; and (3) assess the

impacts of links between adjacent land use/land cover, trophic status, and carbon sequestration rates and storage. Completion of these objectives will identify the potential scale of carbon offsets that could be achieved through wetland restoration and conservation in Ontario.

### Methods

*Study Area* – The study area is southern Ontario (Fig. 1). Within this landscape, a geographic gradient representing climatic and hydrological conditions was established to identify potential sites from where wetlands could be sampled, from west to east: Onondaga (Brant County), Cosford (Hastings County), and Atocas Bay

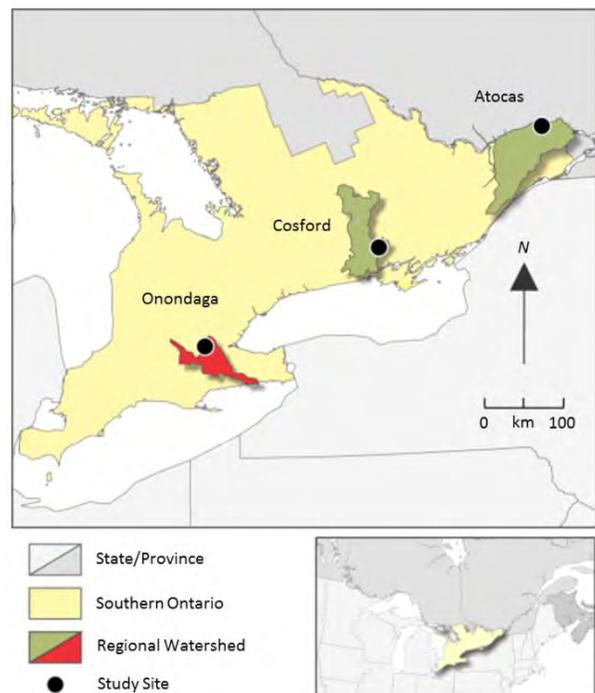


Figure 1. Potential study site locations in southern Ontario with the three DUC sites highlighted along the gradient. Onondaga site which all the preliminary results are based on is highlighted in red.

(Prescott and Russell United Counties) (Fig. 1). Within two of the sites (Onondaga farm and Atocas bay), we focused on (1) small (0.2 to 2.0 ha) and (2) isolated (no inflow or outflow) mineral wetlands that have the greatest restoration potential that included (3) a range of restoration ages to capture potential changes in rates of carbon sequestration with restoration age of wetland. Three replicate wetlands for each of the conditions were sampled: marsh (intact), drained, early restored (3 years since restoration), early/mid restored (6+ years), mid/late restored (20+ years), and late restored (> 35 years). This entire gradient of restoration ages was available only at Onondaga Farms. This report focuses on wetlands sampled at the Onondaga farm site.

*Estimating Magnitude of Wetland Loss* – The magnitude of wetland loss was estimated using the area-frequency power function applied to the wetland inventory in the Southern Ontario Land Resource Information System (SOLRIS; Ontario Ministry of Natural Resources 2008). A negative linear relationship exists between the number of water bodies of different sizes and water body size classes plotted in logarithmic scales in undisturbed settings (Zhang et al. 2009). A non-linear slope indicates wetland change that may be attributed to human activities; the relationship between frequency and area “breaks” at a maximum disturbance size, and below this break the area of wetland loss may be estimated as the area between the observed curve and a linear curve extrapolated from the linear relationship above the threshold. A piecewise 3-segment linear regression was used to extract the break points in the linear relationship.

*Estimating Carbon Stocks* – From each wetland, wetland soil carbon pool samples were collected at four positions: centre of wetland (open-water); emergent vegetation zone; wet meadow zone where flooding often occurs (i.e. high water mark); and upland where flooding rarely occurs. Cores were segmented into 5 cm increments up to 45 cm and analyzed for carbon pools while carbon sequestration rates samples were collected at the centre of wetland (open-water) and segmented into 1 cm increments.

In each wetland and at each sampling location, three replicate cores were collected using a WaterMark Universal Corer (6.8 cm internal diameter) for isotope analysis. In addition, one core was taken from the centre of the wetland using the WaterMark Universal corer for carbon storage estimates, while in upland areas or drier zones, AMS Extendible Corer was used to a maximum depth of 45 cm (maximum compaction 4-5%) to collect samples for carbon storage estimates. Above ground vegetation was removed in the field. Cores were sliced up to 9 sections in 5 cm increments (e.g. 0-5 cm, 5-10 cm, 10-15 cm, 40-45 cm) in the field. Each sample section was placed in a Ziploc bag labeled with sample length interval corresponding to the section. The samples collected from each wetland were sent to Western University’s BIOTRON experimental climate change facility for analysis of organic carbon (Dr. Charles Wu). All carbon storage estimates will be normalized to their mass equivalent following Ellert and Bettany (1995).

*Estimating Carbon Sequestration Rates* – Carbon sequestration rates were estimated from isotopes. We assumed that atmospheric deposition of isotopes Lead-210 ( $^{210}\text{Pb}$ ) and Cesium-137 ( $^{137}\text{Cs}$ ) is spatially uniform. For naturally occurring  $^{210}\text{Pb}$ , it is assumed that atmospheric deposition of  $^{210}\text{Pb}$  is constant temporally and therefore the comparison of  $^{210}\text{Pb}$  concentrations in excess of the known decay curve gives an accurate measurement of sediment deposition rate. For anthropogenically derived  $^{137}\text{Cs}$ , there is a peak in  $^{137}\text{Cs}$  that corresponds to the 1963 global peak emission due to atmospheric testing of nuclear weapons from which an average sedimentation rate since that year can be computed.

Triplicate sediment cores were collected and discretized into 1 cm increments (e.g. 0-1 cm, 1-2 cm, 29-30 cm) using a Submerged Watermark Universal Corer. The three replicate sections from each wetland were composited into one and placed in Whirl-Pak bags. Sediment cores were collected during the summer field campaign (with preliminary sample collection coinciding with the post-melt water sample collection to test and

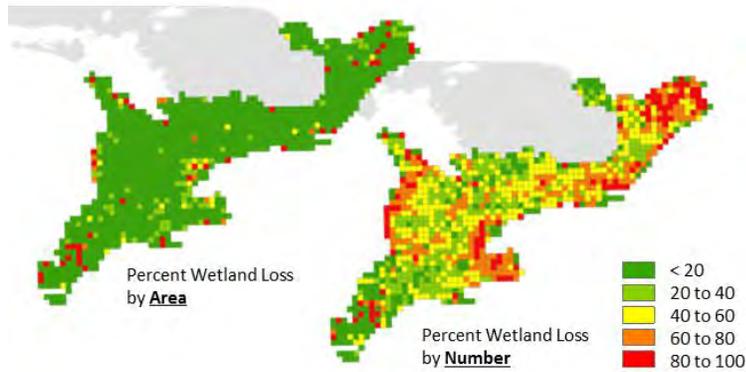


Figure 2. Percent wetland loss in Southern Ontario by area (top left) and by number (lower right). A large number of wetlands (86%) have been lost though the relative area is smaller (21%) as seen in the percent wetland area loss.

refine the sediment sampling techniques to ensure smooth sediment collection during collection of the main samples). Analysis of  $^{210}\text{Pb}$  and  $^{137}\text{Cs}$  concentration in the 1 cm increments was done until background levels were attained (anticipated to be about 30 cm deep). The 1 cm increment provided sufficient resolution considering the likely high degree of physical and biological disturbances that these wetland ponds have experienced. The samples were air dried and passed through a 2 mm mesh sieve, the sediment particles less than 2 mm were weighed and placed in a separate bag while the coarse fraction was also weighed and placed in a bag. Samples were sent to Western University's BIOTRON experimental climate change facility for analysis of organic carbon and to University of Manitoba's Department of Soil Science for isotope analyses (Dr. David Lobb).

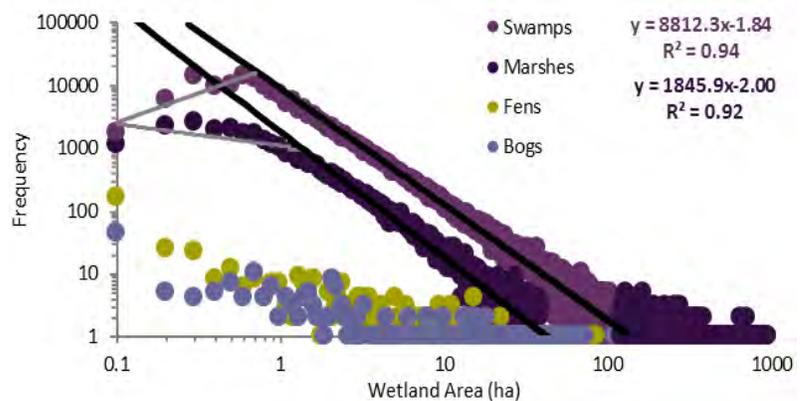
**Results**

**Wetland loss** – An estimated 86% of historic wetlands have been lost comprising 21% of historic wetland area (Fig. 2). Modeling the area-frequency power function for each wetland type (i.e. bog, fen, marsh and swamp), revealed a preferential loss of marshes – an estimated 90% of historic marshes have been lost comprising 39% of historic marsh

area, compared to an estimated 84% loss of historic swamps comprising 18% of historic swamp area (Fig. 3).

By intersecting the SOLRIS wetland inventory with Ontario Hydro Network watercourse features (Ontario Ministry of Natural Resources 2010) wetlands were separated into connected and isolated features. A strong preferential loss of isolated wetlands in southern Ontario was found with an estimated 94% of historic isolated wetlands comprising 53% of historic isolated wetland area loss, compared to an estimated 79% of historic connected wetlands comprising 9% of historic connected wetland area.

**Carbon Stocks and Sequestration Rates** – The carbon stock data are still being analyzed. However, from results obtained for the Onondaga sites (Fig. 4), drained wetlands accumulated 5.1 kg/m<sup>2</sup> of carbon at a rate of 101 g/m<sup>2</sup>/yr. Wetlands restored 10 years ago accumulated 7.1 kg/m<sup>2</sup> of carbon at a rate of 142 g/m<sup>2</sup>/yr. Wetlands restored more than 20 years ago accumulated the highest amount of C at 18.4 kg/m<sup>2</sup> at a rate of 369 g/m<sup>2</sup>/yr. Restoration of wetlands 35 years ago resulted in accumulation of



Power Law Statistics	Swamps	Marshes
Percent number lost	84%	90%
Percent area lost	18%	39%

Figure 3. Power law statistics illustrating percent area and number of wetland loss by wetland type.

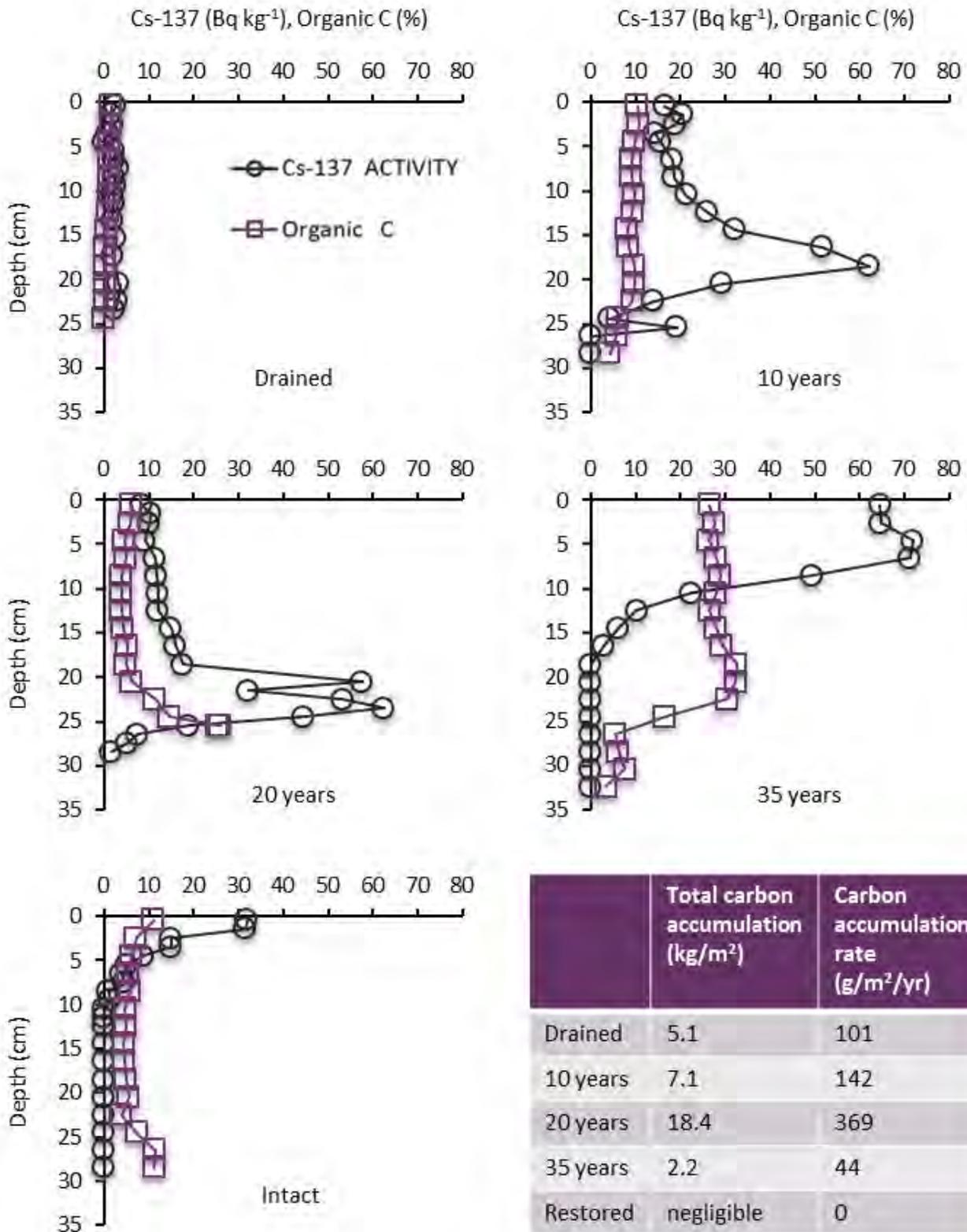


Figure 4. Profiles of <sup>137</sup>Cs and organic C in the 30 cm deep cores collected from Onondaga sites showing the distribution of the <sup>137</sup>Cs isotope and organic carbons within the 1 cm sections.

2.2 kg/m<sup>2</sup> of carbon at a rate of 44 g/m<sup>2</sup>/yr while intact wetlands recorded negligible carbon storage with negligible rate of accumulation.

**Discussion**

The magnitude of wetland loss is estimated to be over 1.5 million ha of wetlands in southern Ontario since the time of European settlement. The percentage number of wetlands lost is higher compared to percent area wetland loss which may be attributed to smaller wetlands being more vulnerable to drainage than larger wetlands. Vulnerability of smaller wetlands to drainage may partly explain the greater number relative to lower area lost relative to the numbers. About 75% of converted wetlands (1.1 million ha) are now classified as “undifferentiated agricultural lands”.

We used our measured carbon sequestration rate Mg CO<sub>2</sub> equivalents ha/yr (Fig. 4) under different scenarios of landowner uptake (ranging from 1 ha to 10,000 ha to 353,160 ha (the estimated historic loss of isolated wetlands within southern Ontario)) using a \$30/Mg CO<sub>2</sub> equivalent price for carbon offsets to estimate carbon sequestration and the value of this sequestration in restored

wetlands (Table 1).

Carbon storage has potential for being a multi-million dollar industry based on current carbon sequestration rates irrespective of whether a lower (52.1 Mg CO<sub>2</sub> eq/yr) or higher (135.5 Mg CO<sub>2</sub> eq/yr) range in the rates of storage is considered during calculation (Table 1). The results further suggested that restoration of wetlands may lead to higher rates of carbon accumulation and sequestration as observed with increase in accumulation and sequestration with increasing age of restoration. Intact wetlands, however, recorded negligible change in sequestration which could be attributed to the fact that the riparian area around them is intact, resulting in organic material from adjacent areas being stored in the riparian area instead of being transported into the wetland. Therefore, the surrounding landscape matrix will need to be considered when determining the potential rates of carbon sequestration through wetland restoration.

The project provides empirical evidence that restoration of wetlands for carbon sequestration could improve the livelihood of farmers and that policies should be established to incentivize

Table 1. Potential economic value of restoring wetlands expressed in Mg CO<sub>2</sub> equivalents when considered both as low carbon storage or high carbon storage potential.

Restored wetland (ha)	Low carbon storage (52.1 Mg CO <sub>2</sub> eq/yr)	High carbon storage (135.5 Mg CO <sub>2</sub> eq/yr)	Economic Value (\$30/yr) of carbon storage based on different estimates	
			Market estimate (\$/Mg CO <sub>2</sub> eq)	
			Low	High
1	52	135	\$1,562	\$4,059
10	521	1,353	\$15,620	\$40,590
100	5,207	13,530	\$156,200	\$405,900
1,000	52,067	135,300	\$1,562,000	\$4,059,000
10,000	520,667	1,353,000	\$15,620,000	\$40,590,000
353,160	18,387,875	47,782,578	\$551,636,264	\$1,433,477,333

\*Note: 353,160 denotes total value of isolated wetland loss

farmers to adopt wetland restoration practices on marginal areas in order to improve the economic performance and environmental sustainability of agriculture in Ontario.

*Next steps* – Further study is needed to: (1) reduce uncertainty in estimates of carbon stocks/rates by sampling additional wetlands and factoring in the landscape matrix which determines the potential carbon loading to the wetlands; and (2) explore the effects of different climate/hydrological conditions across the geographic gradient on carbon stocks/rates. Carbon is only one potential market; current initiatives are looking to the potential markets of wetlands for water purification (e.g. phosphorus removal) and biodiversity. Future studies could explore “bundles” of ecosystem services provided by wetlands.

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## Long Point Waterfowl's Lake St. Clair Initiative: Habitat Selection and Survival of Waterfowl during Migration

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### Introduction

*Current Threats to Waterfowl and Wetlands in the Lake St. Clair Region* – The coastal marshes of Lake St. Clair are a major staging area for waterfowl during both spring and autumn migration (Bookhout et al. 1989, Bellrose 1980). It is evident in the banding record that the area is a crossroads for birds using either the Atlantic or Mississippi flyways, making it a region of continental importance (Fig. 1). Due to extensive wetland drainage and degradation, industrial and urban development, and the impact of invasive

species, the quantity and quality of habitat available for waterfowl has declined dramatically. These changes to the landscape can potentially threaten the area's ability to support migratory waterfowl populations into the future.

*The Lake St. Clair Region* – Lake St. Clair is a large, shallow body of water between Lake Huron and Lake Erie, draining the St. Clair River and forming the world's largest freshwater delta, the St. Clair River Delta (Fig. 2). On the American side, most of the shoreline is under industrial and urban development, while the Canadian side is

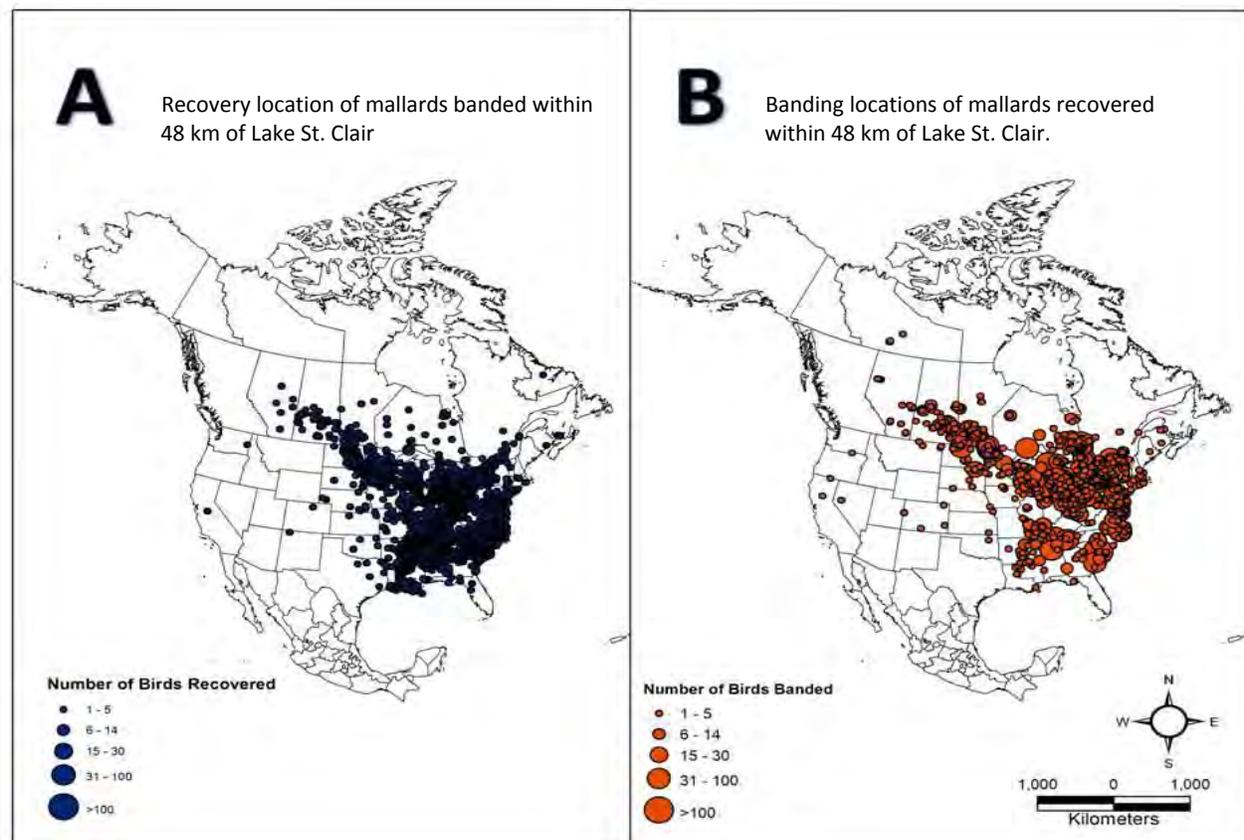


Figure 1. Maps of all recovery locations for mallards banded within 48 km of Lake St. Clair, and banding locations of all mallards recovered within 48 km of Lake St. Clair, to June 2013 (USGS Bird Banding Laboratory).

dominated by agricultural landscapes and some remnant coastal wetlands, most of which have been dyked. More recently, industrial wind turbine projects have become predominant on the landscape, adding to cumulative land use change and a possible additional threat to waterfowl.

Loss of coastal wetlands has been estimated at 81-98% (Bedford 1999, Ducks Unlimited Canada 2010), primarily due to draining, filling, and cultivation for agricultural purposes (Bedford 1999). Remaining wetlands continue to be degraded from various sources such as invasive species. In particular, the exotic, invasive plant *Phragmites australis* is known to outcompete and displace native wetland and marsh meadow plants (Roman et al. 1984, Marks et al. 1984). Monospecific stands of *Phragmites* have expanded throughout most Lake St. Clair wetlands and likely threaten important waterfowl food resources and habitat (Wilcox et al. 2003, Meyer et al. 2012). In addition, non-native mute swan populations have increased in the region over recent years (Meyer et al. 2012). These large swans can affect native waterfowl directly when defending territories and displacing birds from habitats, and indirectly by consuming significant amounts of aquatic vegetation (Petrie and Francis 2003).

#### Long Point Waterfowl's Lake St. Clair Initiative

Since it is anticipated that the human population surrounding Lake St. Clair will continue to grow and threats to remaining waterfowl habitats will intensify, Long Point Waterfowl (LPW) has initiated a project to assess how landscape changes and associated stressors impact waterfowl abundance, distribution, habitat selection, and survival. Our research goal is to provide conservation planners and area managers

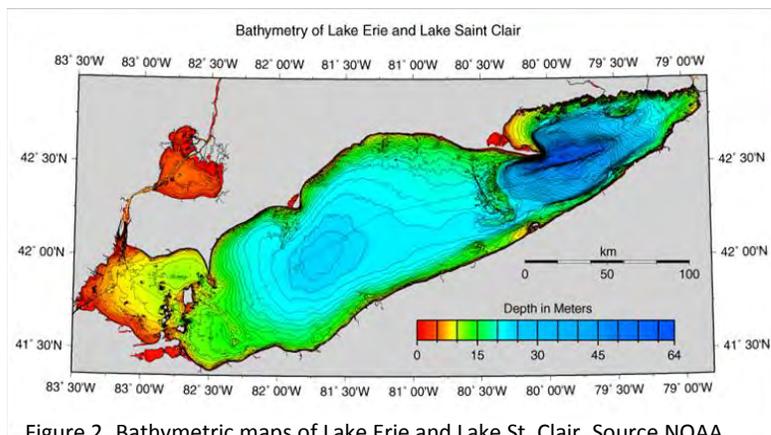
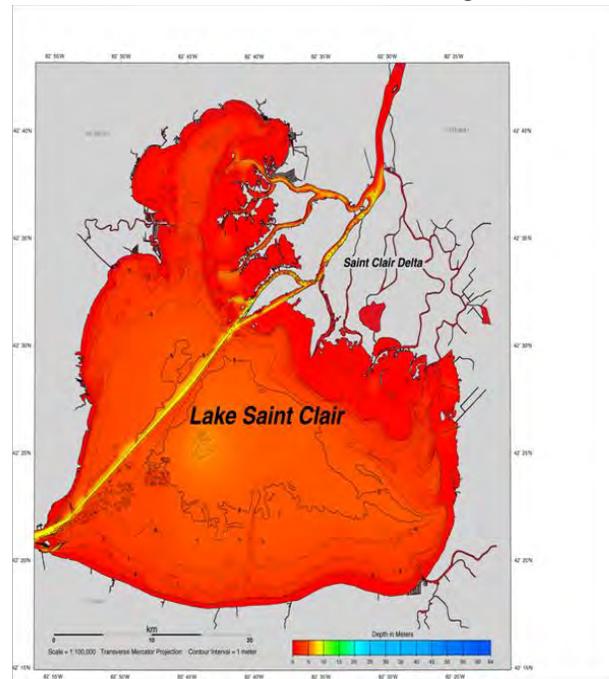


Figure 2. Bathymetric maps of Lake Erie and Lake St. Clair. Source NOAA.

the necessary information to understand how environmental stressors can influence carrying capacity, habitat use, and survival of waterfowl during the non-breeding seasons.

**Phase 1** – In Phase 1 of Long Point Waterfowl's Lake St. Clair Initiative, we are gathering existing information and data sets on waterfowl use and wetland ecology and are developing a report of current conditions. Data sets that we are compiling include waterfowl abundance and distribution data from aerial surveys, banding and recovery data from over 50 years, waterfowl harvest rates, changes in land use practices for agricultural, urban and industrial development. The information gathered is being organized in a document entitled "Waterfowl and Wetlands of

the Lake St. Clair Region: Present Conditions and Future Options for Research and Conservation.” This document will determine the extent of our waterfowl and wetland related knowledge and will identify conservation concerns and major information gaps. In 1998 Long Point Waterfowl developed a comprehensive report of the Long Point Region of Lake Erie called “Waterfowl and Wetlands of Long Point Bay and Old Norfolk County.” The development of this document was pivotal in focusing the direction of research in the Long Point region. We anticipate that this similar document for the Lake St. Clair region also will contribute substantially to the conservation, restoration, and enhancement of wildlife habitat around Lake St. Clair.

*Phase 2* – Phase 2 of the program includes a PhD project to determine habitat use, movement patterns, survival and foraging ecology of waterfowl that use the region during spring and autumn migration. We will use current habitat conservation strategies for migrating waterfowl to assess the amount of habitat needed to sustain waterfowl populations. These strategies are founded on models of energetic carrying capacity that assume habitat use is limited by food energy available to non-breeding birds. But information on the how much food energy is available to migrating waterfowl in Lake St. Clair region does not exist. LPW will assess the energetic carrying capacity of wetland and agricultural habitats that border the eastern shore of Lake St. Clair. Samples will be collected at multiple time periods before and after spring and autumn migrations to assess spatial and temporal changes in food abundance for waterfowl.

Using mallards as a model study species, we will investigate how waterfowl use habitats during their migratory staging and over-wintering period. We have chosen the mallard because recent studies have shown that non-breeding survival is important to sustaining populations in the Great Lakes (Colluccy et al. 2008). We will capture mallards by bait trapping at the beginning of autumn (August-September) and at the beginning of spring migration (February-March). Birds will be equipped with transmitters (30 gram GSM/GPS

solar powered transmitters with an external antenna) to track movement and habitat use for up to three years. Location data can be collected remotely with an accuracy of  $\pm 18$  metres (Microwave Telemetry, Inc.). Transmitters will be attached dorsally between the wings via harness of Teflon ribbon (Petrie et al. 1996, Malecki et al. 2001, Kremenz et al. 2011). The GPS technology will provide accurate locations throughout the day and night to determine daily as well as seasonal movement and subsequent survival.

*Phase 3* – Phase 3 will include additional graduate and undergraduate projects that will address information gaps and concerns identified in Phases 1 and 2.

### **Management Implications**

Long Point Waterfowl’s Lake St. Clair Initiative will provide conservation planners and habitat managers with critical information on what food resources area available to migrating waterfowl, how certain waterfowl spatially and temporally select habitats, and the subsequent impact on their survival.

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# The Great Lakes Marsh Monitoring Program: 18 Years of Surveying Birds and Frogs as Indicators of Ecosystem Health

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## Introduction

The Great Lakes Marsh Monitoring Program (GLMMP) was launched bi-nationally in 1995 by Bird Studies Canada (BSC) in partnership with Environment Canada and the United States Environmental Protection Agency. In 18 years, more than 1400 volunteers have collected data on birds, frogs, and their habitats at more than 5000 unique survey locations throughout the Great Lakes basin. This impressive effort allows BSC to achieve many important outcomes, including:

1. Assess population status and change in birds and frogs at scales ranging from individual marshes to the entire Great Lakes basin;
2. Investigate associations between marsh bird and frog populations and habitat;
3. Contribute to conservation management and planning; and
4. Increase public awareness of the importance of wetland conservation.

Using GLMMP data, I summarized changes in populations of marsh birds and frogs from 1995 to 2012 at various scales within and across the Great Lakes basin, upstream from the Ontario-Quebec border on the St. Lawrence River. The results provide insight into the status of the health of wetland ecosystems throughout the basin.

## Methods

**Surveys**—Marshes were chosen by volunteers or randomly assigned, and were at least 1 ha in size, covered mostly by non-woody plants such as cattails or grasses. Participants conducted bird and frog surveys at 1-8 semi-circular 100 m-radius stations along routes within one or several marshes. Each station was visited 2-3 times during the breeding season in each year. Surveys were timed to maximize the chances of detecting as many species as possible; stations were visited in

mornings or evenings for birds, at night for frogs, and only under favourable weather conditions. Volunteers played calls during bird surveys to entice individuals of especially secretive species to reveal their presence by approaching or vocally challenging the supposed ‘intruder’/surveyor in

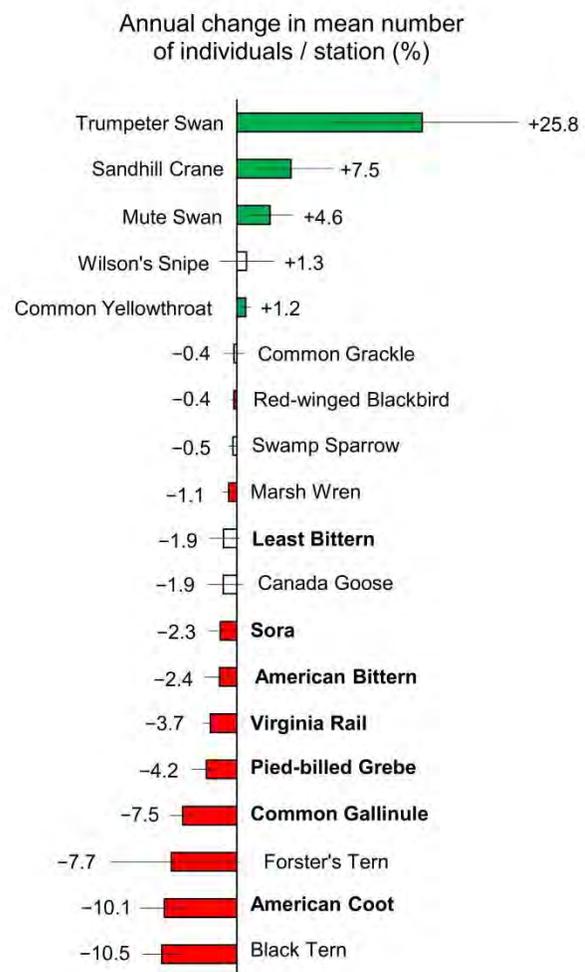


Figure 1. Population trends between 1995 and 2012 in the Great Lakes basin for 19 bird species that regularly or always nest in marshes. Statistically significant trends are shown with green bars (positive trends) or red bars (negative trends); white bars indicate stable trends. Vertical lines are 95% credibility intervals. Populations of half the species declined, including 6 of the 7 focal species (shown in bold; see Results—Birds for a definition).

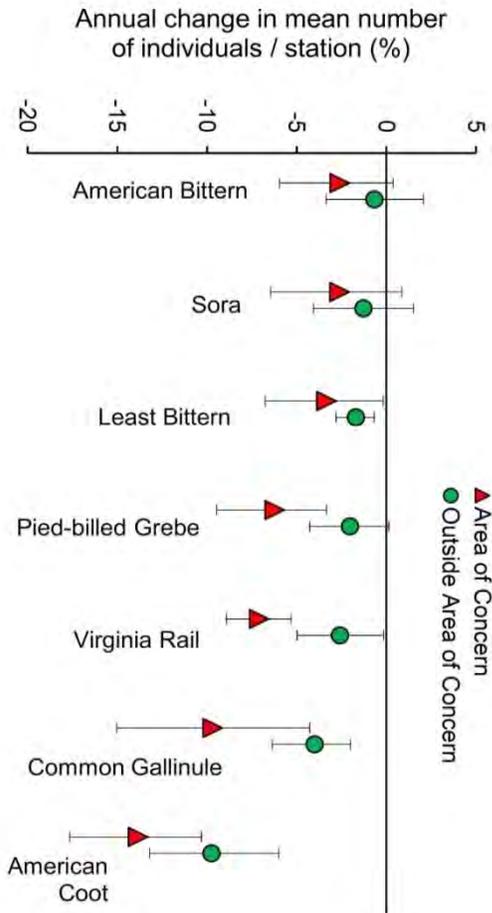


Figure 2. Population trends for focal bird species between 1995 and 2012 inside of Areas of Concern (AOCs) (red triangles) versus outside of Areas of Concern (AOCs) (green circles). Vertical bars are 95% credibility intervals. Although the difference was statistically significant only for Virginia Rail, population trends for all species were more negative within compared to outside of AOCs.

their breeding territory. Habitat information was collected annually at each station. Most stations (90%) were located on shore and were placed to avoid double-counting individuals (more than 250 m apart for birds; more than 500 m apart or back-to-back for frogs). More details can be found in Bird Studies Canada (2009a and 2009b).

**Analyses** – Participants recorded the number of individuals of each bird species identified during each bird survey. I used the maximum number of individuals of a particular bird species from any one of the multiple surveys made at each station throughout the year for analysis, expressed as abundance, or the mean number of individuals per station along a route per year. By contrast,

reliable estimates of numbers of frogs were not possible. Instead, I used the presence of at least one individual of a particular frog species on any one of the multiple surveys made at each station throughout the year for analysis, expressed as occupancy, or the probability of finding at least one individual of a particular species in a station along a route in any particular year. I compared population trends, abundance, and occupancy of different species among different areas to learn more about factors influencing populations.

Population trends over time and abundance or occupancy in each year were modeled at the route level (by including the number of stations as an offset) by using Poisson or logistic regression in a Bayesian mode of inference with uninformative priors and route as a random intercept. Statistically significant differences were determined via Bayesian *p* values or visual inspection of credibility intervals.

## Results

**Birds** – Ten of 19 marsh-associated breeding species (53%) showed population declines across the Great Lakes basin (Fig. 1). Seven of the 19 species—American Bittern, American Coot, Common Gallinule, Least Bittern, Pied-billed Grebe, Sora, and Virginia Rail—were analyzed in more detail below due to their nearly complete dependence on marshes for breeding, and because broadcasts of their calls were used during surveys to increase detections of all but one of them (American Bittern). These “focal species” were among the best indicators of marsh ecosystem health.

Populations of 6 of the 7 focal species (86%) declined across the Great Lakes basin (labeled in bold, Fig. 1). Population trends for most focal species did not differ significantly among Great Lakes basins (insufficient data for Superior); at Great Lakes coastal marshes versus inland marshes; within versus outside of Areas of Concern (AOCs); and among Bird Conservation Regions (BCRs). There were notable exceptions for American Bittern and Sora, both of which increased over time in BCR 12 but decreased over time in BCR 13 and 23.

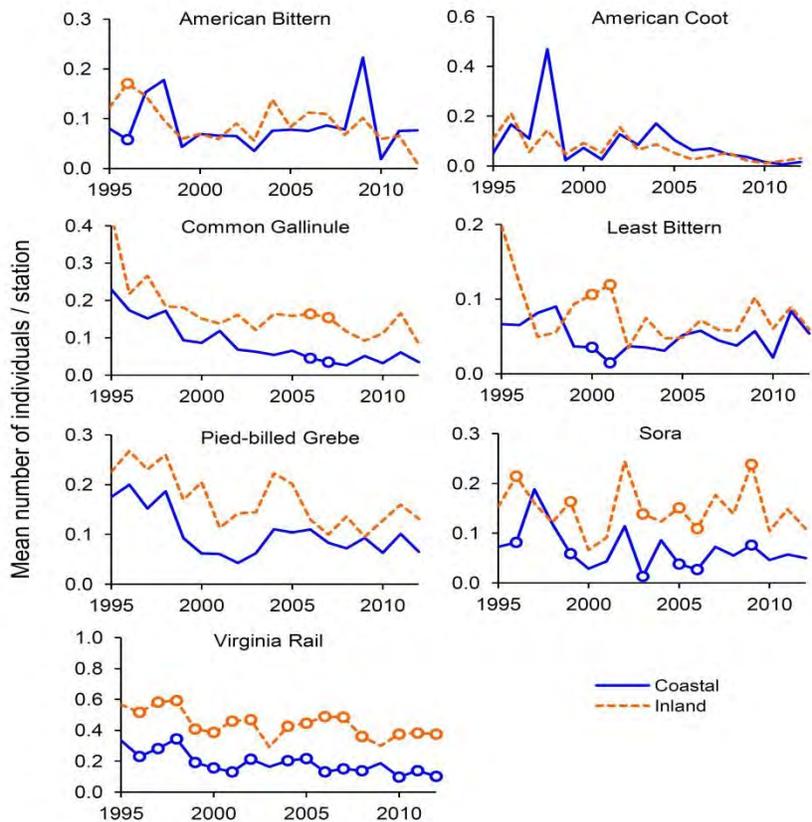


Figure 3. Abundance of focal bird species between 1995 and 2012 at Great Lakes coastal marshes (solid blue lines) versus inland marshes (dashed orange lines). Note the differences in the vertical axes. Statistically significant differences are indicated for years with open circles. Although differences were statistically significant in most years only for Sora and Virginia Rail, abundance for most species was lower in most years at coastal marshes compared to inland marshes.

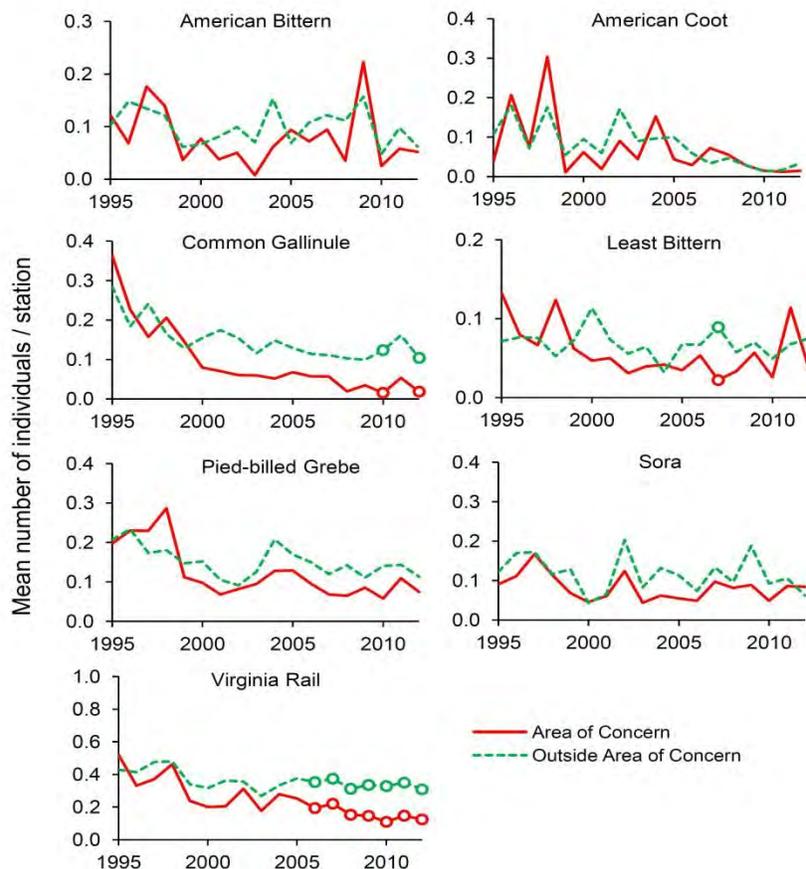


Figure 4. Abundance of focal bird species between 1995 and 2012 inside of Areas of Concern (AOCs) (solid red lines) versus outside of Areas of Concern (dashed green lines). Note the differences in the vertical axes. Statistically significant differences are indicated for years with open circles. Although differences were statistically significant in only a few cases, abundance of most species was lower in most years within compared to outside of AOCs.

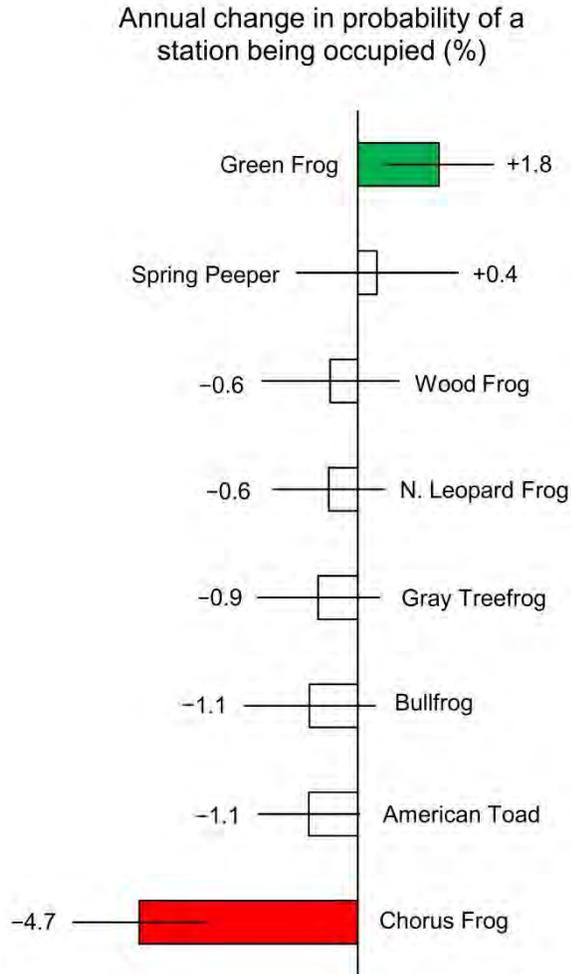


Figure 5. Population trends for 8 frog species between 1995 and 2012 in the Great Lakes basin. Statistically significant trends are shown with green bars (positive trends) or red bars (negative trends); white bars indicate stable trends. Vertical bars are 95% credibility intervals. Populations of most species remained stable.

It is worth noting that population trends for all of the focal species were more negative within versus outside of AOCs (Fig. 2), and abundance of most focal species was lower in most years at Great Lakes coastal marshes and within AOCs than at inland marshes and outside of AOCs (Fig. 3, 4). In most cases, these differences were not statistically significant, but may be important because they occur consistently across many species and years. Although it was short-lived, in 2011 the abundance of the Threatened Least Bittern jumped within AOCs to a level comparable with marshes outside of AOCs and similar to 1995 levels (Fig. 4).

**Frogs** – Six of 8 species (75%) showed stable populations across the Great Lakes basin (Fig. 5). Chorus Frog showed a declining population, whereas Green Frog showed an increasing population.

Population trends for most species did not differ among Great Lakes basins (insufficient data for Superior); at Great Lakes coastal marshes versus inland marshes; and within versus outside of AOCs. There were notable exceptions for Green Frog, which decreased in the Lake Huron basin but increased in each of the other lake basins, and Spring Peeper and Wood Frog, both of which increased within but remained stable outside of AOCs.

Occupancy for most species was lower in most years at Great Lakes coastal marshes compared to inland marshes (Fig. 6). As well, occupancy for Spring Peeper and Wood Frog was lower in most years within compared to outside of AOCs, but recently increased within AOCs to levels similar to areas outside of AOCs (Fig. 7).

### Discussion

Populations of most marsh breeding birds declined between 1995 and 2012 across the Great Lakes basin. By contrast, populations of most frogs remained stable. The prevalence of declining and stable populations of birds and frogs suggests that marsh ecosystem health did not improve across the Great Lakes basin between 1995 and 2012.

It is surprising that there were fewer declining populations among species of frogs compared to birds, because both birds and frogs are thought to be sensitive to changes in marsh ecosystem health. Most of the bird species are migratory, whereas the frog species are not; so it may be that factors beyond the Great Lakes basin (perhaps along migration routes or on wintering grounds) are contributing to bird declines.

Abundance of birds and occupancy of frogs across multiple species and years suggest that marsh ecosystem health was lower at coastal marshes and within AOCs than at inland marshes and outside of AOCs. Environmental stress caused by

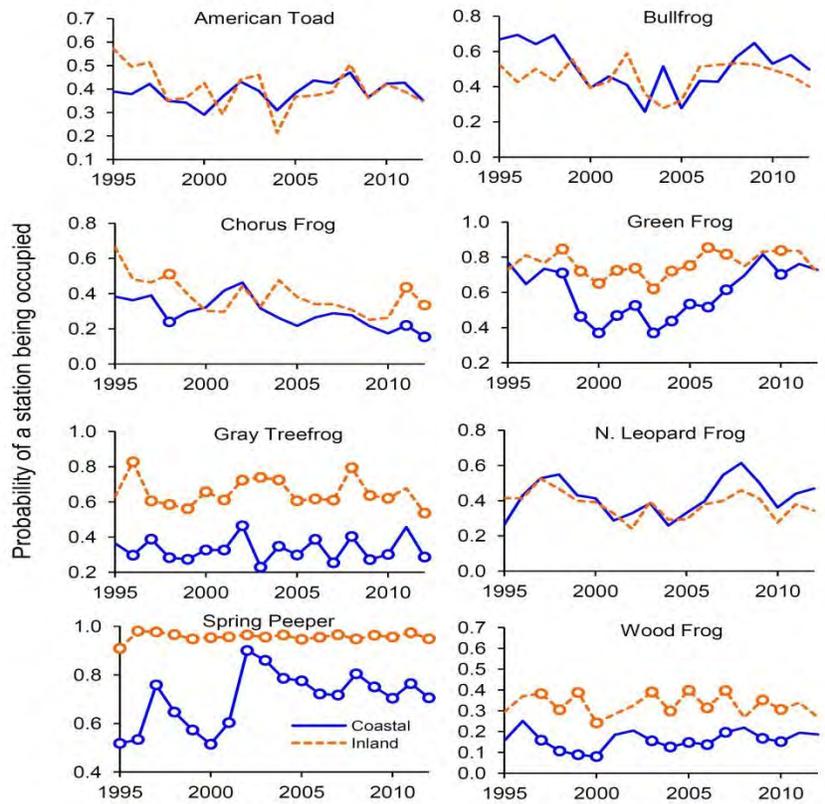


Figure 6. Occupancy of frog species between 1995 and 2012 at Great Lakes coastal marshes (solid blue lines) versus inland marshes (dashed orange lines). Note the differences in the vertical axes. Statistically significant differences are indicated for years with open circles. Occupancy for most species was lower in most years at coastal marshes compared to inland marshes.

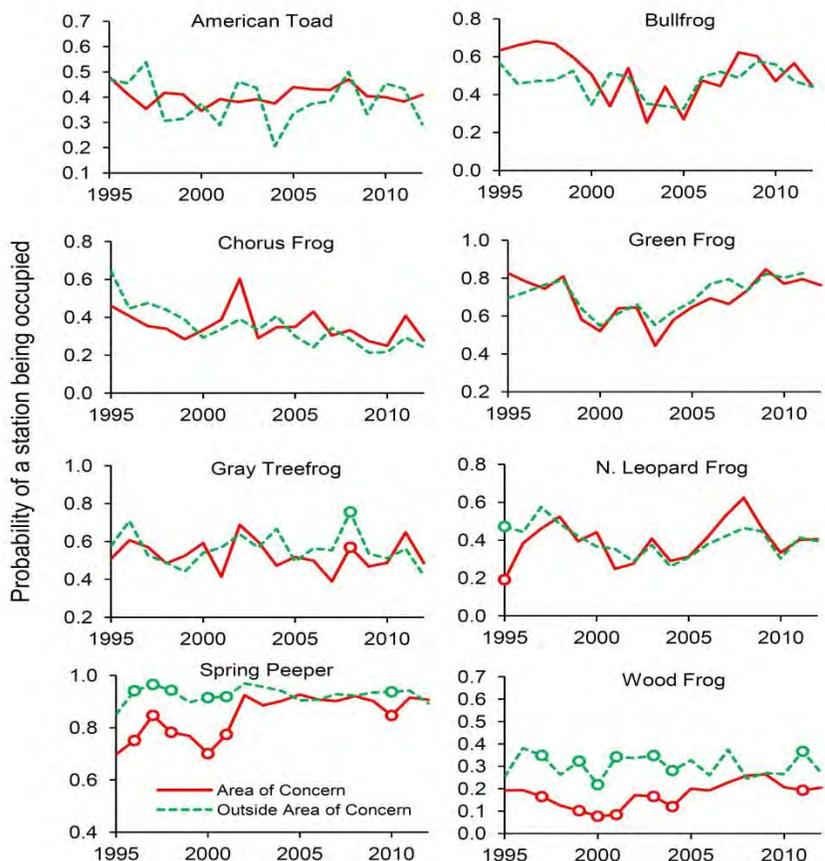


Figure 7. Occupancy of frog species between 1995 and 2012 inside of Areas of Concern (AOCs) (solid red lines) versus outside of Areas of Concern (dashed green lines). Note the differences in the vertical axes. Statistically significant differences are indicated for years with open circles. Occupancy for Spring Peeper and Wood Frog was lower in most years within AOCs compared to outside of AOCs, but recently increased within AOCs to levels similar to areas outside of AOCs.

larger human populations surrounding coastal marshes and within AOCs probably caused or contributed to these patterns, highlighting the need for restoration of AOCs, conservation of coastal marshes, and the importance of relatively healthier inland wetlands throughout the Great Lakes basin.

Even though there was no improvement in marsh ecosystem health overall, there is cause for optimism. Occupancy of Spring Peeper and Wood Frog, species generally considered to be sensitive to environmental stress, increased within AOCs between 1995 and 2012. As well, abundance of the Threatened Least Bittern rose abruptly within AOCs in 2011. Thus, restoration efforts within AOCs appear to be having some positive effects on marsh ecosystem health. There is reason to hope that these and other conservation efforts will result in further improvements in the future across the entire Great Lakes basin.

For more information visit:

[www.birdscanada.org/download/GLMMPreport.pdf](http://www.birdscanada.org/download/GLMMPreport.pdf).

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# POLICY

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*Cranberry Marsh*

*Photo Credit: Central Lake Ontario Conservation Authority*

## Building Tools to Protect Wetlands – the Central Lake Ontario Conservation Authority Experience

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### Introduction

Central Lake Ontario Conservation Authority (CLOCA) is one of 36 Conservation Authorities in Ontario. CLOCA's jurisdiction lies completely within the Region of Durham. CLOCA's mission is to work towards the awareness, understanding, wise use and enhancement of our watershed resources for the benefit of the natural environment in partnership with our municipalities and our community. This paper highlights the tools and actions that CLOCA uses to protect wetlands.

The first part of this paper discusses the importance of building confidence in the data and the value in committing to collect, maintain, refine, improve upon and make available the technical and scientific data. This is followed by a description of 3 fairly recent events that have firmly established the role of Conservation Authorities in protecting natural features, including wetlands, setting the stage for the main body of this paper; a description of tools and actions CLOCA has used to protect wetlands.

Ontario's 36 Conservation Authorities have many varied programs that support wetland protection. With a focus on CLOCA's experiences, one can see the different types of activities and programs that are available. No one program, activity or agency can achieve wetland protection. This paper exhibits that it is the combined effort of CLOCA and its partners that will achieve the goal of wetland protection.

### Setting the Stage - Building Confidence in the Data

Having and using the best available information is vital in the protection of wetlands and over the last couple of decades there have been significant advances in the technical tools to document,

record and map wetland communities. In particular, the use and availability of orthophotography and other programs that capture the characteristics of the earth's vegetation from above, enables the latest changes in land use and vegetation to be recorded and mapped without leaving one's desk. Also, the improved usability of databases has made it less cumbersome to record collected data, conduct statistical analyses, identify trends, and map wetland communities from a database.

Since 1998, CLOCA has used Ecological Land Classification (ELC; Lee et al. 1998), being the provincial standard to classify and map vegetation communities, including wetlands. Using aerial photography at first, CLOCA mapped vegetation communities across the watershed at the Community Series level. With subsequent releases of orthophotography, CLOCA has continued to map, refine and update our ELC database to the Community Series level. This database and mapping is supported by groundtruthing where ELC information is gathered on-site by CLOCA ecologists to the Vegetation Type level. It is this information that allows CLOCA to be able to statistically evaluate wetland coverage and changes in wetland coverage over time on a jurisdiction, watershed, or subwatershed scale. Confidence in the quality and consistency of the database and mapping information is important, yet it is recognized that groundtruthing is necessary to confirm, revise or refine the database and/or mapping. CLOCA's ELC database and mapping is shared with CLOCA's many watershed stakeholders, including Durham Region, local municipalities, consultants, environmental agencies and federal and provincial government bodies. Building and maintaining the quality and confidence in this product is essential as this is the basis for all of

the ecological modeling that is carried out by CLOCA. It is through the concerted effort of CLOCA staff to build, refine and share this mapping and database, and our own recognition that while the mapping is good, groundtruthing is better, that partners and external users of this information have confidence in the quality of CLOCA's ELC expertise, mapping and data.

Building upon CLOCA's ELC database and mapping, CLOCA developed a methodology to identify a Natural Heritage System (NHS) for our jurisdiction. CLOCA's NHS has been customized, reflecting the conditions and management capacities of CLOCA and is described in "Developing CLOCA's Natural Heritage System: A Methodology" (CLOCA 2010). Two key customizations in CLOCA's NHS include aquatic habitat and riparian/wildlife corridors, making CLOCA's NHS a fully connected system. CLOCA's NHS captures all provincially significant wetlands as well as all wetlands  $\geq 0.5$  ha in size that are connected, or easily connected to the system. The NHS provides CLOCA with a scientifically defensible tool to manage watershed resources, including protection of wetlands, and is used to inform municipalities in the development of a municipal NHS and in the identification of significant features for policy development. The NHS is a fundamental component in the development of a number of CLOCA management plans and policies including Watershed Plans and the Central Lake Ontario Conservation Authority Land Acquisition Strategy, providing additional tools at CLOCA's disposal to protect wetlands.

Unquestionably, the development and continued refinement of CLOCA's wetland database and mapping is crucial in the development of CLOCA programs and policies which are used to promote the protection of wetlands, communicate wetland health and identify wetland restoration and enhancement opportunities. Staying on top of an ever-changing technological scene and adopting advancements in technology for mapping, characterizing and protecting wetlands is important. Equally important is the recognition that fieldwork is the best means by which wetlands are characterized and delineated, and

integrating this information into the wetland database is essential.

### **Wetland Protection Tools**

In Ontario there are numerous policies in place that recognize the importance of wetlands and provide tools supporting the protection of wetlands. Provincial legislation and policy include the Oak Ridges Moraine Conservation Plan, the Greenbelt Plan, the *Conservation Authorities Act*, the Provincial Policy Statement (PPS), and others. However, this is not the focus of the paper; for more information, these tools are nicely summarized in "Protecting Greenbelt Wetlands: How Effective is Policy?" (Ducks Unlimited et al. 2012). Before we highlight some of CLOCA's programs that benefit the protection of wetlands, it is important to be aware of some more recent turning points, at the provincial level, that have had significant positive effects on Conservation Authorities abilities to protect wetlands.

The first turning point occurred in 1995 when the Province of Ontario delegated provincial interest in plan review to Conservation Authorities. This delegation of provincial interest is detailed in the Conservation Ontario/Ministry of Natural Resources and Ministry of Municipal Affairs and Housing Memorandum of Understanding on Procedures to Address Conservation Authority Delegated Responsibility (Conservation Ontario, Ministry of Natural Resources and Ministry of Municipal Affairs and Housing 2001). This Memorandum of Understanding (MOU) acknowledged that Conservation Authorities can provide planning advisory services to municipalities for review of *Planning Act* applications, including advice on interpretation of the Provincial Policy Statement (PPS), as well as advice which supports implementation of a Conservation Authority's natural resource management programs. By formally acknowledging this role, Conservation Authorities were identified as the commenting agency to address appropriate management of a watershed's natural resources, including wetlands. The establishment of a service agreement between a Conservation Authority and

a local municipality is the formal mechanism through which a Conservation Authority can provide planning advisory services.

Then in 2004, Ontario Regulation 97/04 (the generic regulation) was passed (pursuant to Section 28 of the *Conservation Authorities Act*), which outlined the content for each Conservation Authority's "Development, Interference with Wetlands and Alteration to Shorelines and Watercourses" Regulation. This was a significant milestone in the protection of wetlands because from this point in time on, all Conservation Authorities must implement and enforce regulations to prohibit, restrict, regulate or give required permissions for certain activities in and around wetlands. The previous Regulation did not specifically include the regulation of wetlands.

Further support for the role of Conservation Authorities in protecting wetlands occurred in 2010 with the release of the "Policies and Procedures for Conservation Authority Plan Review and Permitting Activities" (MNR 2010). This provincially approved document, which was developed by a multi-stakeholder committee with representatives from the province, Conservation Ontario, municipalities, development/building industry and environment sector, clarifies and confirms the roles of Conservation Authorities with respect to municipal planning, plan review and permitting. Similar to the MOU between the Province and Conservation Ontario, this report recognizes that Conservation Authorities can provide a technical advisory role for municipalities "which may include matters related to policy input and advice, assessment or analysis of water quality and quantity, environmental impacts, watershed science and technical expertise associated with activities near or in the vicinity of sensitive natural features hydrogeology and storm water studies" (MNR 2010), including providing advice on interpretation of the PPS. Having the involvement of municipalities and the development/building community in this policy paper ensured that all parties had a voice in confirming the role of Conservation Authorities with respect to protection of natural heritage resources.

With the development and release of the MOU, generic regulation and policy paper, the role of Conservation Authorities in the protection of wetlands as a component of plan review and permitting has been clarified.

### **CLOCA Tools for Protecting Wetlands**

CLOCA uses a number of tools, including regulations, policies, programs, and management plans to support the protection of wetlands. The following provides an overview of some tools CLOCA uses to support wetland protection, starting with permitting and plan review.

*Permitting and Plan Review* – CLOCA has a regulatory responsibility under Section 28 of the *Conservation Authorities Act* to restrict and regulate the use of water in a wetland and/or to restrict and regulate activities that may change or interfere in any way with a wetland. This responsibility is carried out under Ontario Regulation 42/06: Development, Interference with Wetlands and Alterations to Shorelines and Watercourses. Development proposed within a regulated area is reviewed to determine whether the activity would have an impact on the wetland. If the activity would have no impact on the wetland, CLOCA will issue a permit. If an activity would adversely impact a wetland, CLOCA will not issue a permit and the Authority will work with the proponent to find a solution that will avoid creating adverse wetland impacts.

CLOCA provides an important plan review function to our municipalities with CLOCA's roles and responsibilities identified in the Partnership Memorandum with the Region of Durham, and more recently with the City of Oshawa. CLOCA provides technical advice and expertise with respect to the identification, function, and significance of natural heritage features including wetlands. The Partnership Memorandum also recognizes that CLOCA's plan review commenting function shall include identifying if applications are consistent with the wetland requirements of applicable provincial legislation and recommendations of CLOCA Watershed Plans, resource management plans and policies. Each municipality submits, for the Authority's review,

## *Policy*

development applications and planning policy documents. Through this review, CLOCA provides technical expertise and advice with respect to the protection of wetlands including an assessment of potential impacts of proposed activities on wetlands. Of course, through the review of development applications and other planning policies, CLOCA ensures that Ontario Regulation 42/06 is satisfied.

*Policies and Management Plans* – There are a number of policies and management plans that CLOCA has adopted that support the protection of wetlands in various ways. To support decision making with respect to activities in or adjacent to wetlands, as well as all other natural heritage and natural hazard features/functions, CLOCA adopted the CLOCA Policy and Procedural Document (CLOCA 2013). Section 6.4 of this document is dedicated to implementation of Ontario Regulation 42/06 when dealing with wetlands, stating that there shall be no adverse impact on hydrologic and ecological features and functions of the wetland and that activities cannot interfere with the hydrologic function of adjacent wetlands. It is further noted that adjacency can be extended if the activity is deemed to have a measurable impact on hydrologic function. With respect to plan review, guidance has also been provided. Wetlands are clearly identified as a component of CLOCA's Natural Heritage System (NHS) and there are significant restrictions regarding new development within the NHS. The CLOCA Policy and Procedural Document (CLOCA 2013) sets out the decision making framework to assess and determine if an activity may impact a wetland. Having the ability to refer to this document instills confidence and exhibits transparency with respect to decision making regarding the evaluation and determination of applications.

Recently, CLOCA has approved Watershed Plans for the Authority's 4 largest Watersheds. These Plans identify ecological systems that allow healthy watershed targets to be achieved. Key in attaining these targets is the identification of the NHS which includes, among other important natural features, all ELC wetlands greater than 0.5

ha in size and all Provincially Significant Wetlands (PSWs). These Watershed Plans contain recommendations to not only protect the NHS, but have specific recommendations which protect all PSWs and all wetlands greater than 0.5 ha in size by prohibiting new development within wetlands. The establishment of a minimum buffer distance of 15m from ELC wetlands and 30m from all PSWs is required. Also identified in the watershed plans are the High Volume Recharge Areas. These significant groundwater recharge areas are important to identify and protect to ensure a hydrogeological system consisting of sufficient groundwater quality and quantity is sustained in order to support wetlands and other aquatic and terrestrial ecosystems. It is important to note that the CLOCA Policy and Procedure Document (CLOCA 2012) refers to the Watershed Plan recommendations, and specifically the development restriction recommendations for the NHS, including wetlands as important factors in protecting CLOCA's wetlands.

The importance of wetlands is identified in the Watershed Plans and healthy watershed targets to be achieved for watershed wetland coverage are identified in each of the Watershed Plans. The minimum watershed wetland coverage to be achieved is 10% to 12%; 6% for individual subwatersheds. The Plans identify key watershed stakeholders and offer tools and action plans that support implementation of watershed recommendations. A performance monitoring and evaluation framework is also included to guide assessment in the future attainment of wetland targets. Municipalities are identified as a key stakeholder in implementing the recommendations of the Watershed Plans. Currently, local municipalities within CLOCA's jurisdiction are engaged in updating their Official Plans. It is expected that key Watershed Plan recommendations will be implemented through these Official Plan reviews.

Other policies and management plans that are used at CLOCA to protect wetlands include Conservation Area Management Plans and Land Acquisition Strategies. Conservation Area Management Plans are prepared for Conservation

Areas with the key management goals being the protection, maintenance and enhancement of the ecological integrity of these areas. Public education and recreational opportunities are supported provided they do not threaten the health and natural productivity of the area. The 'environment first' principles that guide management of Conservation Areas ensure the natural heritage features, attributes, functions, and systems of these areas are protected. The Land Acquisition Strategies have provided guidance and direction in securing the most ecologically significant features and functions within CLOCA's jurisdiction. Ecologically significant lands have been identified for acquisition based upon sound natural heritage system planning drawing upon information generated through CLOCA's Natural Heritage System modeling, ELC mapping and data, Watershed Plans, and Conservation Area Management Plans.

#### **CLOCA Protecting Wetlands Through on the Ground Action**

While these programs and tools support the protection of wetlands, it is the dedicated and consistent implementation of these programs and tools that result in marked progress in wetland protection. For the most part, it is changes in land use that have a significant impact on wetlands. As such, municipal understanding and willingness to implement wetland protection policies, including adoption of wetland protection policies in Municipal Official Plans and other land use policies, plays a key role in the protection of wetlands. In CLOCA's jurisdiction, Regional and Municipal Official Plans identify the need to protect wetlands for their significant ecological values. Wetlands are mapped in Official Plans and policies recommend protection of these wetlands. These Municipal Official Plans also include policies that protect wetlands that may not be mapped.

Education efforts that continue to improve municipal understanding of the important role wetlands play in overall watershed health is paramount. Not one agency or organization is responsible for this education, but we must, as Conservation Authorities lead by example. CLOCA

takes a number of approaches to educating municipal partners regarding the important value of wetlands. CLOCA advocates for the incorporation of Watershed Plan recommendations and adoption of CLOCA's NHS in Municipal Official Plans and other municipal land use policies as a means to entrench wetland protection in municipal planning and land use decisions. Another approach CLOCA has taken is a more hands on approach whereby we meet with municipal staff in the field and explain the value and importance of wetlands, often identifying ways a particular wetland can be protected, enhanced and/or restored. For instance, CLOCA's plan and permit review functions require staff to confirm and delineate wetland community boundaries. This work is done in the field in consultation with the proponent/landowner, municipal staff, and environmental consultants. This practice enables prudent and judicious decisions to be made regarding the wetland community including size, limits, rarity, value and overall sensitivity; all-important components when considering impacts of future and/or planned development. Conducting this field work and being consistent in deliberation is essential in gaining the respect of municipalities, landowners and developers. Acquiring this respect goes miles in ensuring the protection of wetlands.

Certainly, having wetland protection policies in place and decision makers consistently implementing those policies is vital. Also important is improving the level of knowledge and understanding of the crucial roles wetlands play in the watershed through community stewardship, outreach, education and monitoring efforts. Recently, a landowner contact program has been initiated in the Harmony/Farewell Iroquois Beach Wetland Complex and adjacent Maple Grove Wetland Complex area where a concentration of PSWs and ELC wetlands exist. This is a rural area dominated by small (1-20 acre) parcels held in private ownership. For this project, CLOCA's stewardship work is focused on contacting interested landowners, delineating and mapping wetland communities and edges and sharing best management practices with the landowners,

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instilling a greater understanding of the importance of wetlands in the overall health of the watershed. Other projects CLOCA have worked on with private landowners include wetland habitat enhancement, naturalization of wetlands, wetland restoration and implementation of a variety of best management practices to reduce and/or eliminate unsuitable landowner/wetland interactions. Collaboration with landowners can result in significant advancement in wetland protection. For example, arising out of a partnership to construct a 3 cell wetland, a long term commitment to wetland stewardship and education evolved, supported by an annual wetland conservation golf event with proceeds supporting wetland stewardship projects and wetland education programs. This lasting partnership is an excellent example of the unanticipated benefits arising from a specific project, including empowering landowners to become champions for stewardship, generating additional projects and encouraging landowners to undertake other habitat projects.

CLOCA's long term watershed monitoring program monitors the health of wetlands and includes bird and amphibian monitoring, aquatic monitoring, salamander monitoring, water quality, sediment quality, and terrestrial monitoring of wetland communities. CLOCA also conducts the Durham Region Coastal Wetland Monitoring Project (DRCWMP). This long term monitoring program has been monitoring the health of 18 coastal wetlands along the north shore of Lake Ontario since 2002. This project relies on a suite of partners to carry out annual monitoring including federal government agencies, provincial agencies, other Conservation Authorities and dedicated volunteers. Information collected from these monitoring programs feeds back into the database, continuously improving the level of information and quality of data that CLOCA has and shares with watershed stakeholders. Long term monitoring enables CLOCA to continually improve upon the characterization of the health and condition of our wetlands and identify trends and changes in wetland health. Through monitoring, CLOCA can

identify stressed wetlands and advance recommendations for the protection of these wetlands.

But by far, the best way to ensure lasting protection of wetlands is through public lands securement. By using the guidance of the Land Acquisition Strategies, CLOCA has been able to secure just over 6,000 acres of the most ecologically significant features and functions within our jurisdiction, 21% of which are wetlands. The remaining 79% are made up of largely valleylands, forests, and grasslands, all areas that contribute to the health and protection of wetlands by providing supporting habitat and vital groundwater recharge and discharge functions. To acquire ecologically significant lands, support is required. CLOCA has partnered with a variety of organizations including Ducks Unlimited Canada, the Province, Ontario Heritage Trust, the Oak Ridges Moraine Foundation and a multitude of other agencies. All together, these partners have offered up to 26% of the funding needed to protect critical wetlands in our watershed. In addition to these partners, the Region of Durham and local municipalities have played a significant role in supporting acquisition. The Region of Durham has a land acquisition funding policy for Durham Region's five Conservation Authorities. This funding policy outlines a process and eligibility requirements whereby the Conservation Authorities can apply for funding from the Region's Land Acquisition Reserve Fund to finance the acquisition of properties for conservation purposes. Since 2000, the Region has contributed 28% of the funding required to secured 3215 acres of ecologically significant lands within CLOCA's watershed. CLOCA's local municipalities have also been supportive in protecting wetlands through acquisition, providing about 7% of the funding required. Acquisition needs resources and support; and in this economic climate finding the resources and partnerships to support securement is increasingly difficult. A continued commitment to build relationships with partners and future partners, including landowners, is very important. Having municipalities and decision makers that comprehend the value of wetlands in

a healthy watershed, and who are willing to financially support acquisition is to be applauded. Without the financial support of the Region of Durham, local municipalities and other partners, CLOCA's protection of wetlands through acquisition would not be where it is today.

### Conclusion

Conservation Authorities are responsible to develop the programs necessary to effectively manage natural resources and to ensure that these resources continue to contribute to a healthy, diverse, and sustainable ecosystem. It is the development, adoption and implementation of these programs that enable Conservation Authorities to have a positive impact on the protection of wetlands within their watersheds. This paper describes a number of the programs CLOCA uses in the protection of wetlands including regulations, policies, programs and land securement. The integrity of these programs is underscored by a recognized commitment to continuously improve the data, monitoring, assessment and mapping of wetlands. Sharing the information generated and continuing to build and maintain partnerships is also important as the protection of wetlands does not fall to any one agency or organization, we must work collectively to protect our wetlands.

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## Selling Wetland Conservation to Municipalities: The Value of Wetlands as Green Infrastructure

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### Introduction

Ducks Unlimited Canada (DUC) is the leader in wetland conservation. As a registered charity, DUC partners with government, industry, non-profit organizations, and landowners to conserve wetlands that are critical to waterfowl, wildlife and the environment. Using sound science, DUC delivers on-the-ground habitat projects, research, education programs, and public policy work to conserve, restore, and manage wetlands. Since 1938, DUC has conserved over 6.4 million acres of wetland and associated habitats across Canada.

DUC works with all levels of governments, advocating for programs and policies that benefit wetlands and stop critical wetland loss. In Ontario, DUC government relations efforts are designed to influence policy, legislation and regulations, budget, and programming both at the provincial and municipal levels. One might ask: why municipalities? At DUC, we believe that municipalities are on the front lines of wetland conservation. Municipalities are the primary implementers for Ontario's land use planning system. Working directly with landowners and the public, municipalities have the ability to affect vast areas of wetland through development decisions, promotion of best management practices as land is being developed, and encourage wetland stewardship through public education. Most wetlands in southern Ontario are not protected by provincial policies, so municipalities have an opportunity to step up and go beyond the minimum standard to protect their wetlands, not just the provincially significant ones.

### Provincial Policy Framework

Although there is a federal policy for wetland conservation, there is no overarching wetland or water policy or legislation for the Province of

Ontario. In Ontario, wetland-related policies are scattered across a number of different legislation and ministries. The two provincial policies that speak most directly to wetland conservation on a municipal scale are: the Provincial Policy Statement (2005) issued under the *Planning Act* and the *Conservation Authorities Act* (1990).

The Provincial Policy Statement (PPS) sets the ground rules for land use planning in Ontario including the protection of provincially significant wetlands from various forms of development. This policy is primarily implemented by municipalities and other planning authorities and applies mostly on private land.

The *Conservation Authorities Act*, through Section 28 regulations, allows Conservation Authorities to 'prohibit, regulate or require permission' for 'interfering with wetlands' or when development involves risks of flooding, erosion, and pollution.

Although the policies are in place to protect wetlands in the province, in Southern Ontario only about one third of all wetlands are protected from development by the PPS. Research shows as of 2002, southern Ontario had lost 72 per cent of its wetlands (> 10 ha) over the last 200 years (Ducks Unlimited Canada 2010). In some regions wetland loss is more than 90 per cent and the wetland habitat that remains is under increasing threat. Ontario continues to lose wetlands at an estimated 3500 ha per year for large wetlands (> 10 ha) (Ducks Unlimited Canada 2010). Therefore, Ontario's policy framework is not as effective as it needs to be – that is why municipalities are a significant player in the protection of Ontario's remaining wetlands.

### Communicating Wetland Benefits for Municipalities

The concept of green infrastructure is not new, there are a number of different definitions out

there some speak specifically to natural and green systems that provide a range of ecosystem services and others to designed or engineered systems that replicate natural ecosystem functions. Whatever way you look at it, green infrastructure is about the consideration of both the natural and built environment in planning and development decisions.

DUC's municipal extension program empowers municipal decision makers and implementers to conserve wetlands with information and science about the values of wetlands as green infrastructure. The overall goal of our program is to increase the level of protection afforded to wetlands by strengthening municipal policies. We engage particularly with municipalities that are undertaking official plan or policy reviews. Increasing the protection of wetlands through the land use planning process is an effective tool and strategy for DUC, and will ensure that wetlands continue to be recognized for the ecological goods and services that they provide to Ontario communities and economy.

A big part of municipal extension, with both urban and rural municipalities, is communicating the value of wetlands as natural green infrastructure using ecological goods and services messaging. Wetlands are essential components of watersheds and critical for ecosystem maintenance. Healthy wetlands provide communities with numerous services including water filtration and purification, flood prevention and mitigation, water storage, erosion control, mitigation of greenhouse gas emissions and recreation. This range of services provides municipalities with numerous economic, social and environmental benefits.

In order to work with municipalities to realize the value of wetlands, DUC focuses on the natural capital value of natural green infrastructure. More and more scientific and economic studies are showing that preserving natural systems creates more benefits for local communities than replacing them with engineered (or hard) infrastructure, and is arguably more cost effective as well (Green Bylaws Toolkit 2007). To demonstrate, we will focus on three key services

provided by wetlands that are relevant to sustainable water management and municipal infrastructure planning: water purification, flood control, and carbon sequestration/climate change mitigation.

*Wetlands and Water Quality* – Wetlands help to maintain and improve water quality – by acting as natural filters they remove a significant amount of pollutants and sediments from our lakes, rivers and streams. According to an Environment Canada study, it is estimated that Canada's wetlands provide \$1.35 billion annually in water purification services. (National Wetlands Working Group 1988). Aquatic plants like duckweed have been found to reduce levels of both phosphorus and nitrates mostly found in surface water runoff flowing into our watercourses (DeBusk and Reddy 1987). Studies have shown that wetlands reduce nitrate and phosphorus by about 80% and 94% respectively (Olewiler 2004). By removing nutrients that cause algae production and reduced oxygen, wetlands help improve quality of the water not only for fish and other aquatic creatures but also for humans. As wetlands feed our streams, rivers and lakes downstream, they also recharge the groundwater that supplies community drinking water sources.

In 2011, DUC published a "*Business Case for Wetland Conservation: The Black River Subwatershed*" that examined the ecological value of wetlands and the economic impact of wetland loss in the Black River subwatershed of the Lake Simcoe basin (Fig. 1). This DUC research helped to re-establish a dollar value for services of local wetlands. The study found that the wetlands in the Black River subwatershed (7,590 ha) removed harmful phosphorus from Lake Simcoe, saving municipalities about \$300,000 a year in water purification services. The report concludes that wetlands along the Black River are critical to meeting the phosphorus objectives of the Lake Simcoe Protection Plan. In addition to other wetland values estimated in the study, wetlands provide a total of \$435 million per year in ecological services to the Lake Simcoe watershed alone (DUC 2011). Therefore, maintaining existing



Figure 1. Black River (Source: Ducks Unlimited Canada 2011).

wetlands will provide the highest return on investments for municipalities.

*Wetlands and Flood Control* – In addition to helping improve water quality for fish and people, wetlands also help mitigate flooding conditions. Wetlands naturally absorb and store a significant amount of water from the surrounding watersheds. One acre of wetland can typically store about a million gallons – an area equal to about  $\frac{3}{4}$  of a football field covered in almost a metre of water (US Environmental Protection Agency 2006). After absorbing and filtering rain, snowmelt, and surface runoff, the stored water is then slowly released as flow into downstream watercourses or through aquifers (Fig. 2). Additionally, by decreasing the flow of flood

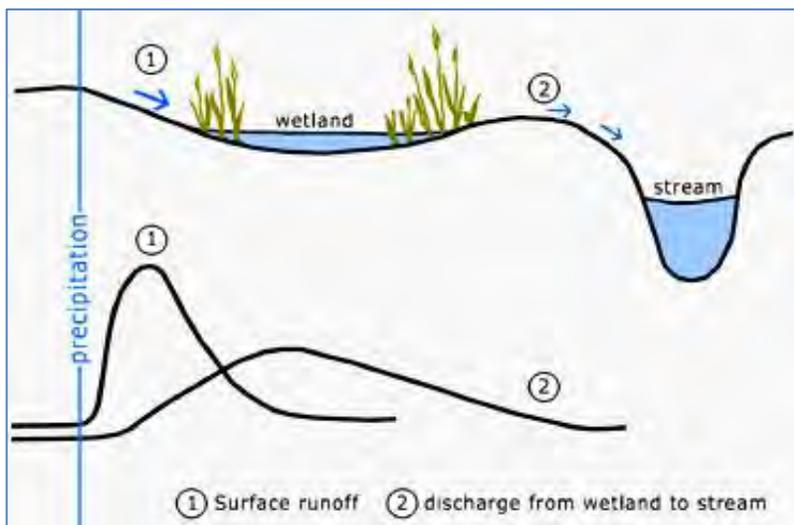


Figure 2. Wetland retention of surface runoff (Source: www.forestandrange.org, from Mitsch and Gosselink 2000).

waters (Fig. 3), wetlands also help reduce soil erosion, flood heights and the resulting potential for destruction downstream (Wetland Stewardship Partnership 2010).

Therefore, when wetlands are altered or drained, the probability that a storm or rainfall event will cause flood damages increases significantly (Gabor et al. 2004). An Environment Canada study showed that Canada’s wetlands provide flood control worth \$2.7 billion annually (National

Wetlands Working Group 1988). In the US, the Federal Emergency Management Agency actually encourages the use of wetlands for storm water detention either in lieu of, or in conjunction with, traditional structural flood control measures (US Environmental Protection Agency 2006). A study in the US Mississippi River Basin found that restoring wetlands within the 100 year flood zone could store the amount of flood water that caused the Great Flood of 1993, causing over \$16 billion in projected flood damage costs (US Environmental Protection Agency 2006). Another study found that the loss of 3400 hectares of wetland in the Charles River Watershed near Boston would result in \$17 million (US) in flood damages per year – a value equivalent to each hectare of wetland providing \$5,000 worth of flood control each year (Environment Canada 2002). Therefore, conserving wetlands is a more natural, less expensive solution to controlling flooding than the construction of dikes and dams alone. These values should encourage municipalities to protect wetlands with sound land use decisions and engage in other conservation activities such as restoration and stewardship.

*Wetlands and Climate Change* – Lastly, studies have started to show that wetlands play a role in carbon sequestration, mitigating

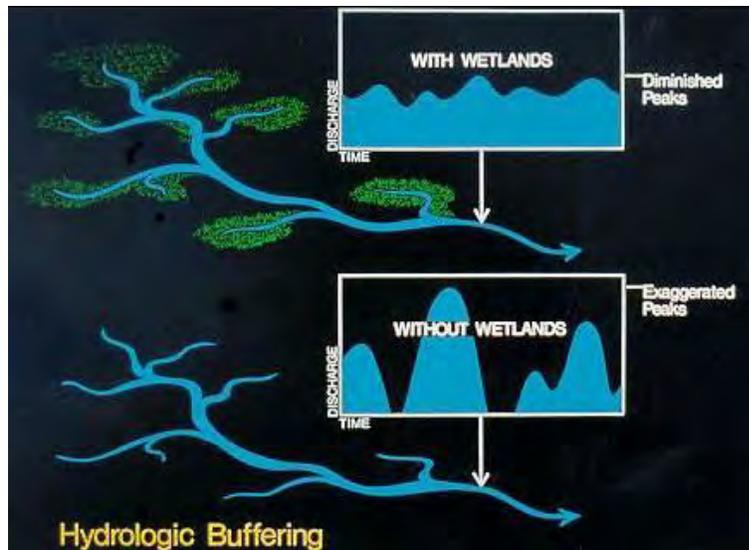


Figure 3. Wetlands provide hydrologic buffering (Source: Alberta Wilderness Association, from "Forested Wetlands: Functions, Benefits and the Use of Best Management Practices," U.S. Government).

rising CO<sup>2</sup> levels and the impacts of climate change. The high productivity and waterlogged conditions of wetlands allow them to take in carbon dioxide and release oxygen, making them excellent 'carbon sinks' (Mitsch et al. 2013). It is estimated that Canadian peatlands store approximately 56% of the soil organic carbon in Canada (Wetland Stewardship Partnership 2010). Ontario's boreal forest is home to one of the largest peatlands and carbon storage reserves in the world and the largest wetland complex in North America (Hudson Bay-James Bay Lowlands).

Until recently, there has been very little information on the rate of carbon sequestration in mineral wetlands in Southern Ontario, either natural or disturbed. A few studies in Ohio compared several different types of wetlands by looking at both carbon sequestration and methane emissions. The results showed that regardless of greenhouse gas emissions (e.g. methane), most wetlands have a significant carbon storage rate, the highest being tropical and peat-forming wetlands (Mitsch et al. 2013). Temperate freshwater wetlands, while not as significant as tropical wetlands or Canada's boreal peatlands, still have the ability to provide carbon sequestration services, contributing to offsetting

Canada's greenhouse gas emissions and climate change.

DUC is hoping to further Ontario carbon research by leading a new study to help facilitate the development of a carbon offset (a tradable permit representing the right to emit carbon dioxide) that will generate financial incentives that encourage landowners to restore and conserve wetlands on their lands. The results of the study will help support the economic valuation of ecological goods and services associated with wetland conservation and restoration. It is leading research like this and the resulting innovative solutions that will help to encourage municipalities to understand the true value of their wetlands.

### Conclusions and Key Messages

In conclusion, conserved and restored wetlands help municipalities save money! Even on a small scale, individual developers can save significant costs if existing systems are maintained, rather than constructing replacements. When wetlands are damaged or destroyed, it is difficult, if not impossible, to replace those functions. We have seen that draining wetlands often leads to other issues and costs – including increased flood damages, erosion and sediment problems, decrease in local tourism and recreation, decreased fish and harvestable wildlife populations, and loss of biodiversity. With new climate change projections for rising temperatures and increase in extreme weather events, the issue of wetland loss is becoming more important every day. Municipalities need to consider investing in their green infrastructure and protecting their wetlands in order to build resilience.

Based on the valuation of ecological services and leading-edge wetland science referenced in this paper, DUC staff continue to work with municipalities to improve wetland conservation across southern Ontario. It is well-recognized that

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the environment and wetlands are important on a local scale, yet balancing the environment with several other competing interests is a real challenge for municipalities. Putting a monetary value on wetlands helps to build a competitive business case for the services that wetlands provide as an important element of municipal green infrastructure. Furthermore, in the event that the wetland has to be converted for the greater public good, then proper compensation is easier to determine if a wetland has a specific value allocated to the functions and services it provides. It is easy to dismiss the economic value of green infrastructure to municipalities, but it is a key element of healthy and sustainable communities. Wetlands definitely have the potential to help mitigate future water management problems. Thus, it is important to communicate the value of wetlands to municipalities and people of Ontario in terms that resonate with them – services, costs, economic and social benefits. Development decisions will be better informed if you are comparing apples to apples rather than apples to oranges.

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# The Renewed Great Lakes Water Quality Agreement

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## Introduction

The Great Lakes Water Quality Agreement (GLWQA) is an agreement between Canada and the United States, first signed in 1972. It contributes to the quality of life of millions of Canadians by identifying shared priorities and coordinating actions to restore and protect the chemical, physical and biological integrity of the waters of the Great Lakes (Environment Canada 2013a).

## The Agreement

The original 1972 GLWQA focused primarily on reducing algae; with both nations agreeing that a coordinated approach to limiting phosphorus inputs was the key to controlling excessive algal growth. Actions that followed resulted in an unprecedented success in achieving environmental results and demonstrating the value of binational cooperation (Environment Canada 2013a).

In 1978, the GLWQA was revised to reflect a broadened goal "to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem." It introduced the "ecosystem approach" for identifying, managing and preventing environmental problems around the Great Lakes. This approach recognized the interconnectedness of all components of the environment, and the need for an integrated perspective in addressing human health and environmental quality issues (Environment Canada 2013a). Further, it included a new focus on toxic substances in the Great Lakes ecosystem.

The GLWQA was amended again in 1987, and the concepts of Lakewide Management Plans and Areas of Concern were introduced (Environment Canada 2013b). Forty-three areas in the Great Lakes were identified as having severely degraded environmental quality. Currently there remain 9

Areas of Concern in Canada, 25 Areas of Concern in the United States, and 5 additional Areas of Concern shared by both countries (Environment Canada 2013b).

In the revised 2012 GLWQA, Canada and the United States have updated and strengthened a shared vision, common objectives and commitments to science, governance and action that will help to restore and protect Great Lakes water quality and ecosystem health. The GLWQA retains its focus on restoring and protecting the water quality of the Great Lakes, but its scope has been expanded to include habitat and species, as they are an integral component of healthy aquatic ecosystems, and the full range of issues which threaten the waters of the Great Lakes, including aquatic invasive species and climate change (Environment Canada 2013a).

With these strengthened commitments, roles and responsibilities have been clarified and new opportunities for engagement of the various levels of governments, First Nations, Metis, watershed management agencies, stakeholders, and the public have been solidified, thus sharing the responsibility for restoring and protecting the Great Lakes.

## The Habitat and Species Annex

The new Habitat and Species Annex of the GLWQA includes a commitment to conduct a baseline survey of the existing habitat against which to establish a Great Lakes Basin Ecosystem target of net habitat gain and measure future progress. Co-led by Environment Canada and the US Fish and Wildlife Service, the Annex subcommittee has developed a workplan; the agencies will work to coordinate with other organizations and stakeholders to implement the actions identified. Through this coordinated effort, an approach to inventory existing surveys of habitats and species will be completed.

Recommendations will be developed for establishing targets for net habitat gain based on the lakewide Biodiversity Conservation Strategies, Lake Ecosystem Objectives, existing programs and supporting science (Environment Canada and the US Fish and Wildlife Service 2013). In its infancy, the team is comprised of members from both Canada and the US who possess in-depth knowledge and experience in the processes, practices, and challenges of spatial mapping and large-scale habitat monitoring. The U.S. National Wetlands Inventory Program and the Binational Coastal Wetlands Monitoring Program have been identified as valuable wetland pieces for the inventory.

Great Lakes ecosystem health is dependent on sustaining the processes and functioning of the various systems of the Great Lakes: open waters, near-shore land and waters, and watersheds. A measure of the health of these systems can be expressed in terms of biodiversity. Wetlands are integral to the health of biodiversity of each of the Great Lakes. By 2015, Biodiversity Conservation Strategies are to be developed for each lake, and implementation begun (Environment Canada 2013c). The Lake Ontario strategy is complete, and an implementation plan has been developed by the Lake Ontario Lakewide Action and Management Plan agencies. Biodiversity strategies for lakes Superior, Huron, Erie, and Michigan are in various stages of development. Development of the strategies was through a multi-jurisdictional and multi-stakeholder science-based process and reflects a wide range of interests and goals for the lakes. The strategies contain evaluations of viability, threats and priorities and recommend strategies to abate the most critical threats and enhance the health of the biodiversity features. A Biodiversity Strategy Task Team has been formed, comprised of both US and Canadian representatives to work with their Lakewide Management Annex counterparts, to identify priority actions for habitat and species restoration, protection, and conservation, as described in the Strategies, and to begin to implement actions through existing programs and agreements.

### **Great Lakes Integrated Nearshore Framework**

There continue to be challenges to Great Lakes nearshore water quality and aquatic ecosystem health. New and re-emerging threats to water quality caused by population growth and urbanization, agricultural intensification, aquatic invasive species, and the impacts of climate change are, in combination, having an adverse impact on water quality. Impaired water quality is contributing to the resurgence of toxic and nuisance algal blooms, beach closures, loss of habitat and species, and lack of ecosystem resilience. The amended GLWQA commits Canada and the US to increase their understanding of the cumulative impacts of the multiple stressors acting on nearshore waters, and developing management strategies for both restoring nearshore areas under high stress, and preserving nearshore areas of particular social, economic, and ecological value (W.F. Baird & Associates Coastal Engineers Ltd. 2013). By 2016, development of an integrated nearshore framework (to be subsequently implemented collaboratively through the lakewide management process for each of the Great Lakes) is to be completed.

With a focus on the Great Lakes coastlines, coastal wetlands will be receiving renewed attention. Taking a consensus-based approach to assessment, priority setting, and integrated management that reflects the needs of the Great Lakes, the Nearshore Framework (when implemented) will:

- Assess the state of the nearshore waters;
- Identify areas with high stress and high ecological value;
- Identify factors and cumulative effects that are causing stress or that are threatening areas of high ecological value;
- Establish priorities for nearshore protection and restoration; and
- Identify and engage the appropriate agencies and entities with a focus on the nearshore.

Consideration will be given to nonpoint source runoff, shoreline hardening, climate change

impacts, habitat loss, invasive species, dredging and contaminated sediment issues, bacterial contamination, contaminated groundwater, and other factors where they are identified as a source of stress to the nearshore environment (Environment Canada 2013d).

### Conclusion

Great Lakes coastal wetlands are a significant ecological, biological, economic, and aesthetic resource. They are important habitats for many species of plants, fish and wildlife. Coastal wetlands also have other important functions. For example, they help to reduce damage from floods and erosion, and remove excess nutrients from surface waters. Great Lakes coastal wetlands are in peril as indicated by the decrease of coastal wetland area, declining wetland-dependent bird and amphibian populations and deteriorating plant community health (Environment Canada 2013e). The revised Great Lakes Water Quality Agreement is comprehensive and action-oriented, and is intended to strengthen collaborative actions in order to contribute to the recovery of native species populations and to achieve a net gain in habitat. In order to protect water quality, we must support ecosystem health by ensuring the resilience of native species and habitats, and this will surely include coastal wetlands.

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## Is it Time for a Comprehensive Wetland Policy in Ontario?

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### Introduction

This paper will make the following argument: we need to rethink and redesign wetland policy if Ontario is going to meet its goals concerning water quality and supply, climate change adaptation, biodiversity, and sustainable infrastructure. The environmental and economic costs of not doing so are simply too great. Is the best solution a made-in-Ontario overarching and comprehensive wetland policy?

There are strong reasons to develop a comprehensive wetland policy for Ontario. Firstly, the environmental and economic values of wetlands are currently not fully recognized and protected through policy and programs. This is despite the fact wetland environmental values are well-documented, and there is a growing body of research that confirms the associated economic values of wetlands. For example, three recent studies found that wetlands in central Ontario are valued at between \$11,172 and \$31,716 per hectare per year. In each study, wetlands were found to be the most highly valued type of natural cover, followed by forests (David Suzuki Foundation 2008, Wilson 2008, Kennedy and Wilson 2009). Secondly, wetland conservation is an efficient and cost-effective tool to help Ontarians and the Ontario government tackle several significant issues such as: threats to biodiversity, persistent water quality problems (e.g. phosphorus), need for infrastructure renewal/reducing the infrastructure deficit, and adapting to more extreme weather patterns and other impacts associated with climate change. The proven societal benefits of wetlands combined with the persistent loss of wetlands and their services call for a new approach to wetland policy in Ontario.

There are models in other jurisdictions that we can look to for guidance but ultimately what a new wetland policy in Ontario would look like

depends on the interests and ideas put forward by all stakeholders. To develop a new wetland policy approach will require much discussion and collaboration. Ducks Unlimited Canada (DUC) would like to help advance that discussion in forums such as this conference.

### Status and Threats of Ontario's Wetlands

Ontario's population is projected to grow by 28.6 per cent, or almost 3.9 million, over the next 24 years, to almost 17.4 million by 2036 (Ministry of Finance 2013). As Ontario's population continues to grow, so does the potential for conflict between competing land-uses and wetlands. Research shows as of 2002, southern Ontario had lost 72 per cent of its wetlands (> 10 ha) over the last 200 years. In some parts of Ontario, wetland loss is more than 90 per cent and the wetland habitat that remains is under increasing threat. Ontario continues to lose wetlands at an estimated 3,500 ha per year of large wetlands (>10ha) (Ducks Unlimited Canada, 2010).

In southern Ontario, the biggest threats to wetlands continue to be development pressures (e.g. urban expansion) as well as the accompanying infrastructure, and intensifying agricultural land use practices. (Ducks Unlimited Canada 2010). Other important threats include aggregate extraction, existing land uses, peat extraction (in localized areas) and water takings (Ducks Unlimited Canada et al. 2012). In the near north and far north regions of Ontario, wetland threats are less well understood but mining and forestry activities are likely the most significant causes of wetland impact (French Planning Services Inc. 2009).

### Current Policy Framework Concerning Wetlands

Unlike some jurisdictions, Ontario does not have one overarching wetland or water policy or legislation; instead, wetland-related policy and regulation is embedded in several policies and

legislation. The three provincial policies that speak most directly to wetland conservation in Ontario are:

- Provincial Policy Statement (PPS) – issued under the *Planning Act*, sets the ground rules for land use planning including protection of provincially significant wetlands, and implemented by municipalities; only applies to private land.
- Section 28 regulations of the *Conservation Authorities Act*, implemented by Ontario's 36 conservation authorities (CAs), give powers to CAs to 'prohibit, regulate or require permission' for 'interfering with wetlands' or for development if the development meets certain tests (e.g. if it affects flooding, erosion, pollution, etc.)
- The *Far North Act* (2010; FNA) provides a legislative foundation for First Nations and the Ontario government to work together on community based land use planning in the Far North (which covers over 40% of the Province). The FNA allows for sustainable development of the region's natural resources and protects at least half of the Far North of Ontario (including significant acreage of wetlands) in an interconnected network of protected areas.

*What's working in the current framework:*

- Progress is being made in reducing the financial burden and delays in obtaining permits and approvals for wetland conservation projects. Many people do not realize that wetland restoration and management activities typically require 2-4 permits and approvals, which can add significant costs and/or delays to project implementation or even rejection of potential projects (even when simple, low risk restoration techniques are employed). The most common permits and approvals required are: approval under Section 28 regulations under the *Conservation Authorities Act*, a Permit to Take Water under the *Ontario Water Resources Act*, and sometimes approval under the *Lakes and*

*Rivers Improvement Act* and the Class EA for MNR Resource Stewardship and Facility Development Projects. This is a significant unintended consequence of the current, disjointed set of wetland-related policies in Ontario, which reduces the amount of wetland conservation activity in Ontario.

- Provincial land use plans that apply to a specific geography, like the Greenbelt Plan are working well to minimize wetland impacts from most forms of development. A report co-authored by DUC (in partnership with other NGOs), titled "Protecting Greenbelt Wetlands", found that there is more legal protection to wetlands in the Greenbelt than in other parts of Ontario.
- There is a trend in southern Ontario for more municipalities to adopt land use plans that exceed the minimum requirements in the Provincial Policy Statement, thereby protecting more wetlands. Municipalities such as the City of Kawartha Lakes, Grey County and Chatham-Kent have recognized the environmental and economic values of wetlands and adopted policies that afford protection to wetlands that are not protected by the PPS (i.e. wetlands not deemed to be provincially significant).

*Where the current framework can be improved:*

- In parts of Ontario where agricultural production and land values are high, such as southwestern Ontario, there continues to be pressure to convert wetlands and other natural areas into agricultural land use (a situation exacerbated by the recent steep rise in commodity prices and prices for agricultural land). There is no better example of this threat than the case of St. Luke's Marsh, a large provincially significant wetland located on Lake St. Clair. St. Luke's is currently up for sale and there is an imminent risk of the land being sold and the marsh being converted to agricultural uses (or other uses). DUC believes this risk to be high because two nearby significant coastal wetlands were sold and converted to

agriculture uses. As we understand, there are no policies or regulations in place (federal, provincial, or municipal) that would prevent the sale and conversion of this highly valued wetland. We think this points to a major gap in the current policy framework that needs to be rectified in a timely fashion.

- The Goulbourn Wetland Complex (Ottawa) is an example of a gap in wetland protection pertaining to the designation of wetlands as “provincially significant” and the use of the *Drainage Act*. In the 2009/2010 Environmental Commissioners of Ontario Annual Report, the ECO states that “Rural landowners in the City of Ottawa were able to use the *Drainage Act* to bypass provincially significant wetland protection provisions in the Provincial Policy Statement”. We agree with the recommendation in that report that the PPS should be revised to restrict *Drainage Act* works, such as new and petition drains in provincially and locally significant wetlands.
- The third example of where the effectiveness of provincial policies can be improved to better conserve wetlands is regarding the impacts of urban sprawl on wetlands and the implementation of the *Place to Grow Act* and related policies. There is concern that the precedent being set in cases like the Regional Municipality of Waterloo’s Official Plan (OP), being overridden when a sprawling development that conflicted with the OP was approved by the Ontario Municipal Board (OMB). Part of the Region’s OP that the OMB overruled was a policy that sets an intensification target that exceeded the minimum target established in the *Place to Grow Act*. Critics of this decision have rightly stated that the OMB’s decision was tantamount to creating new provincial planning policy.

**What do we mean by a comprehensive wetland policy (CWP) and what would it look like?**

A CWP would take into consideration the multiple interests of the organizations that have an

interest in wetlands and their conservation. First and foremost, it would recognize wetlands as critical landscape features because of the range of benefits (ecological goods and services) they provide. A CWP would also set the vision and long-term objectives and outcomes to be achieved for wetlands across the province, and it would inform and direct government policy and programs that have a bearing on wetland conservation. A CWP would not be Ministry-specific and, like the provincial Biodiversity Strategy, would provide a policy framework for all provincial ministries to consider in developing their policies, regulations, and programs.

An Ontario CWP could have the following elements:

- A shared vision for Ontario’s wetlands that recognizes the environmental and economic value of wetlands: We believe that the strongest and most durable wetland policy would be based on a shared vision amongst all stakeholders, including government and non-government organizations, and the public. In support of this vision, we suggest that there a set of high-level objectives (and outcomes attached to those objectives). For example, a CWP could have objectives that speak to:
  - Wetland protection;
  - Wetland restoration and management; and
  - Adaptive management (including research and information needs).
- An overarching goal of no net loss of wetlands: Several jurisdictions with CWP, or policies with similar elements, have adopted an overarching goal of no net loss (or net gain) of wetland extent and function. The premise behind a no net loss goal is that, in certain circumstances, wetland loss will be unavoidable, for example due to prohibitive costs and/or a competing use of land being in the greater public interest. In such cases, the policy would stipulate that compensation or off-setting is necessary to replace the lost wetland and its functions.

- A mitigation sequence/hierarchy: To effectively achieve a goal of no net loss and to ensure avoidance of impacts is the first priority, a mitigation sequence or hierarchy is essential. Many jurisdictions, including the federal government, have incorporated a three-part mitigation sequence which asserts that avoidance of the wetland should always be the priority, followed by minimization of the impact, and finally, when residual impacts cannot be minimized, there should be compensation (Cox and Grose 2000).
- Inclusion of all types of wetland conservation policies, programs, and activities: a strong and durable CWP should, in our opinion, include the full range of programs and activities that are necessary to ensure long-term success in achieving the vision and overarching goal(s) of the CWP including stewardship programs, education and communications, research and monitoring as well as policy tools. The CWP should also promote all aspects of wetland conservation, namely protection, restoration, and management (at the site level and program level).

*Examples of comprehensive wetland policies (or similar types of policies) in other jurisdictions*

At least five other jurisdictions in Canada have developed a CWP (or wetland policies with similar elements to a CWP). The following two recent examples illustrate some differences and similarities in different approaches that have been taken in Canada.

The 2013 Alberta Wetland Policy has its roots in the province's *Water Act* and the 2003 Water for Life strategy which was a response to a multi-year drought. The Strategy identifies the protection of Alberta's aquatic ecosystem as one of its three goals; and the implementation of a provincial wetland policy is one of the key actions in support of that goal. The province-wide policy focusses on four high-level outcomes, which include 1) protecting wetlands "of the highest value" 2) conserving and restoring wetlands "in areas where losses have been high" and 3) the three

part wetland mitigation sequence. The policy "will provide a comprehensive suite of tools and guidelines to support an effective...wetland management system".

The 2011 Nova Scotia Wetland Conservation Policy has a goal of 'preventing the net loss of wetland in Nova Scotia' which is narrower in scope than goals of the Alberta Wetland Policy. However, like the Alberta policy, it prioritizes the protection of wetlands with the highest value/significance, and incorporates the wetland mitigation sequence. Both the Alberta and Nova Scotia wetland policies clearly state that minimizing or preventing wetland loss must be done in a way that also allows for economic development. Both policies also emphasize the need and provide support for effective stewardship programs as an important complement to wetland policies and regulations.

**Next steps towards a comprehensive wetland policy for Ontario**

As noted, development of a CWP for Ontario would require extensive consultation with all sectors, including government and non-government organizations and the public. We see this as a critical step moving forward, to ensure buy-in and commitment from all stakeholders. This would result in a draft CWP document endorsed by a coalition of supportive non-government organizations including key industry sectors. The next step would be to engage and seek support for the draft CWP from a broader audience including government.

Based on the experience of other provincial jurisdictions, we expect the entire process to develop and approve a comprehensive type of wetland policy will take several years. In the interim, components of a CWP and/or supporting activities (e.g. research and monitoring, landowner and public outreach and stewardship programs) can and should be advanced by the government and non-government organizations. Activities to stem on-going wetland loss and degradation and restore wetlands must be adequately resourced and accelerated to meet the on-going pressures and threats to wetlands.

## Summary

To meet the on-going threats faced by wetlands and capitalize on their environmental and economic values, wetland stakeholders should give full consideration to developing an Ontario comprehensive wetland policy, informed by the experiences of other jurisdictions. A comprehensive wetland policy that recognizes the full value of wetlands, lays out a long term vision and promotes all types of wetland conservation activity (e.g. protection, restoration, and management) could move Ontario much closer to becoming a sustainable wetland province.

The consequences of not having an overarching provincial wetlands policy include more conflict on the landscape and persistence of the current complex and fragmented policy framework. Real and lasting success in conserving Ontario's wetlands will hinge on a new shared vision for wetlands and commitment by all stakeholders (government, non-government, and the public), as part of a new approach to wetland policy.

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## CONSERVATION AND MANAGEMENT

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*ALUS Restoration Project in Norfolk County  
Photo Credit: Ontario Nature*

## ***Phragmites australis* at the Crossroads: Why We Cannot Afford to Ignore this Invasion**

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### **Introduction**

European reed or *Phragmites australis* (here after referred to as *Phragmites*) is an aggressively spreading non-native, invasive grass. *Phragmites* is considered to be the most aggressive invasive species of marsh ecosystems in North America (Bains et al. 2009) and Canada's worst invasive plant (Catling 2005). It was first observed in Ontario along the St. Lawrence River in 1916 and was later discovered on Walpole Island, Lake St. Clair in 1948 (Catling and Mitrow 2011). Rapid expansion occurred throughout Southern Ontario during the 1990's and this robust grass is now established in many Lake Erie and Lake Huron coastal wetlands, and is also beginning to get a foot hold along Lake Superior's coastline (Fig. 1). It is also a common sight along Southern Ontario's major highways, secondary roads, and agricultural drains which act as significant spread vectors. The threat to Provincially Significant Wetlands and globally rare ecosystems is considerable and increases annually, as does the cost and effort required to bring *Phragmites* under control.

Unlike in the United States, effective control options for expansive, well established cells are inadequate in Canada, and nonexistent when surface water is present. Currently, large scale control efforts are limited to dewatered sites which greatly restricts efficacy. Without the availability of herbicides approved for overwater

application the loss of wetland habitat has the potential to be cumulatively devastating. There is also a need, on a restricted basis, for aerial herbicide application to enable the control of *Phragmites* in large, remote, and difficult to access locations. The availability of these two options requires direct federal government action.

Over the long term, there will be a need for alternative control options and support for innovative research must continue. Emerging research on novel ways to control *Phragmites*, such as gene silencing and bio-controls are currently being investigated (see Great Lakes *Phragmites* Commission website). Research on bio-controls is ongoing by a research team lead by



Figure 1. Canadian Great Lakes coastal wetlands with invasive *Phragmites*, observed by lead author, 2005-2013.

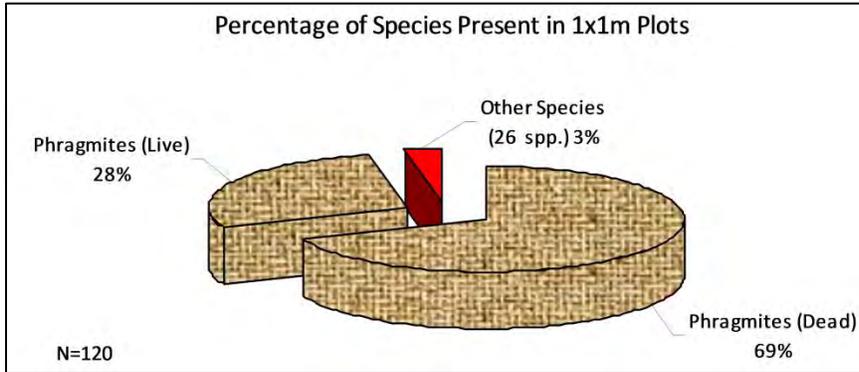


Figure 2. Data collected within plots established throughout a dense invasive *Phragmites* cell, Rondeau Provincial Park, 2007.

Dr. Blossey at Cornell University (this laboratory was instrumental in identifying the appropriate beetles to control the once troublesome purple loosestrife). Dr. Blossey and colleagues have identified a few potential insects; however, these moths also target the native *Phragmites australis* subsp. *americanus* which may hinder progress for this control option. Even if a release program is implemented within the next few years, it will take many more years before any noticeable impact takes place given the considerable biomass, extent, and exponential growth of *Phragmites*. Ultimately, the advent of natural controls provides the only long-term viable solution for dampening the spread of this highly aggressive plant. However, the amount of habitat impacted during the estimated several decades, if not centuries (if *Typha angustifolia* is any indication), that will pass before this will take



Figure 3. New shoots of invasive *Phragmites* plants growing out of the rhizome from one parent plant, St. Joseph Island, Lake Huron, 2011.

effect dictates that action be undertaken now wherever possible. It is also important to note that even where this strain of *Phragmites* occurs naturally in Europe, it has developed into monoculture stands and been problematic (www.agroatlas.ru, White 2009, Gusewell 2003, Asaeda et al. 2006).

Despite the existing restrictions and constraints, restoration success is being achieved on a site-by-site basis using methods outlined in the provincial *Phragmites* Best Management Practices document. However, the expansive infested sites require significantly higher control efforts, dedicated funds, and project coordination, as well as overwater approved herbicides and therefore, are largely left unmanaged. Also, due to the extensive presence of *Phragmites* within some localities, the probability of a restored site becoming re-colonized remains high unless a regional control program is concurrently being undertaken. Invasive *Phragmites* has become so pervasive throughout Southern Ontario that a large scale, well-coordinated effort is now required to achieve any meaningful control. Given the aggressive spreading nature of *Phragmites* and its current and projected impacts, ignoring



Figure 4. Expansive invasive *Phragmites* cell in a Lake Erie coastal wetland, Rondeau Provincial Park, 2012.

the problem and adopting a non-control option is not a viable or defensible option. Province-wide, *Phragmites* management is achievable, but only with a well-funded, well planned, coordinated approach undertaken by grass-roots organizations fully supported by municipal, provincial and federal governments.

This paper provides: 1) summary information on the impacts of *Phragmites*, 2) the challenges currently hampering effective, efficient, and environmentally responsible control, and 3) a summary of *Phragmites*-related initiatives.

### ***Phragmites* Impacts**

*Phragmites* is capable of out-competing all other plant species including cattails (*Typha* spp.), willows (*Salix* spp.), alders (*Alnus* spp.), and buttonbush (*Cephalanthus occidentalis*). Plants can exceed 5 m in height and reach densities of over 180 stems per square metre (Saltonstall 2005; Gilbert et al. 2009a, 2009b). The high aboveground biomass is supported by an even greater amount belowground, and roots may extend downward several metres to attain required water and nutrients making the plants strong competitors for available nutrients. The brittle, standing dead stalks from previous years are slow to decay and can impede wildlife movement and cut and puncture skin. In most stands, dead stems account for ~70% of the total number of *Phragmites* stalks present (Fig. 2; Gilbert et al. 2009b, Gilbert unpublished data). In addition, *Phragmites* is allelopathic (Bains et al. 2009), and has high evapo-transpiration and biomass accretion rates which tends to reduce water levels.

*Phragmites* colonizes new sites via seed and rhizome dispersal, but once established, spreads colonially via rhizomes. These can emanate from each parent stalk in all directions and have been observed at 30 m lengths with new shoots emerging ~30 cm (Fig. 3). Once established, *Phragmites* cells can expand at an exponential rate eventually joining together to create extensive mono-culture stands (Fig. 4). The subsequent decline in native plant diversity and community composition directly impacts



Figure 5. Dead Blanding's turtle found in a large invasive *Phragmites* cell, Rondeau Provincial Park, 2013.

wildlife through loss of suitable habitat. While bird, reptile and amphibian usage have been observed within narrower tracts and along the edges of expansive monoculture *Phragmites* cells, interior areas are effectively dead zones.

Within coastal ecosystems, the presence of dense *Phragmites* cells has the potential to be cumulatively devastating for many wetland dependent species, including a number of species at risk (SAR) which depend upon these habitats for all or a portion of their life cycle. Negative impacts on SAR turtles (Fig. 5) and the endangered Fowler's toad in particular are becoming more apparent (Bolton and Brooks 2010, Gilbert 2011, Davy, pers. comm. 2013, Gillingwater, pers. comm. 2013, Green, pers. comm. 2013). For humans, *Phragmites* negatively impacts aesthetic and recreational values by blocking views and making access to shorelines difficult and unpleasant. Traffic hazards from blocked views at intersections and fire hazards

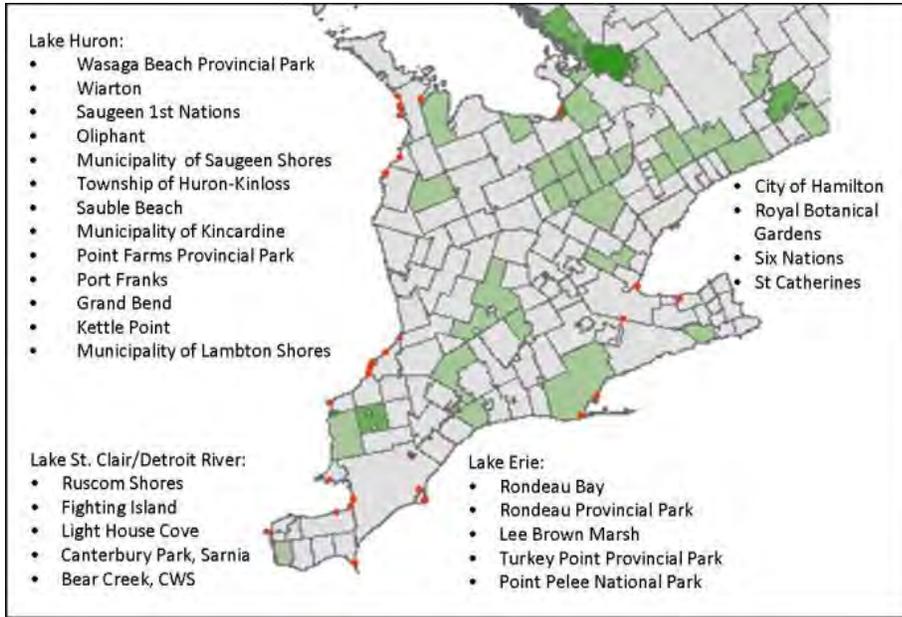


Figure 6. Invasive *Phragmites* control project locations, 2007-2013.

during the dormant season are increasing, especially in residential areas.

**Management Challenges**

Effective control methods in Ontario are limited, site specific, and minimal to non-existent for wet sites. Many non-chemical control options including cutting, drowning, smothering, covering, excavating, plowing, grazing, and burning have been attempted with varying success. Control efficacy was related to cell density, size, site conditions and labourer tenacity. Each of these mechanical control methods has limitations and can also have very negative ecosystem impacts (Gilbert 2013).

The most effective and efficient control of

*Phragmites* in the United States has been achieved using glyphosate (Rodeo®, AquaNeat®, AquaPro®, Shore Klear™) and imazapyr (Habitat®) based herbicides. These products can legally be applied over water and aerially and have an efficacy of between 80 – 100% control after one treatment (Marks et al. 1993, Derr 2008, Avers et al. 2009). The best results have been obtained when glyphosate and imazapyr were combined (Mozder et al. 2008). These chemicals kill the plant by

shutting down key enzyme production within the belowground structures. Since these same enzymes are not present in non-plant life, the chemicals pose little risk to humans and wildlife and are considered safe for aquatic ecosystems (Solomon and Thompson 2003, Wojtaszek et al. 2004, Struger et al. 2008, Extoxnet 2010). Rodeo, Habitat and other overwater approved herbicides are not available in Canada. Legal chemical options here are limited to two products, Weathermax® and Vision®, and although both products are glyphosate based, neither can be applied over water. This is because they also contain the surfactant polyethyloxyated tallowamine (POEA) which is harmful to aquatic life (Perkins et al. 2000, Howe et al. 2009).



Figure 7. *Phragmites* control program at Kettle and Stony Point First Nation showing a) dense invasive *Phragmites* in coastal meadow marsh pre-control, b) same location during 1<sup>st</sup> growing season post-control and c) comparison in *Phragmites* densities pre-/post-control.

Vision<sup>®</sup>, which is more expensive, is used by the forestry industry and can be applied aerially. Weathermax<sup>®</sup> is the best option available for on-the-ground *Phragmites* control when no surface water is present.

A number of considerations must be taken into account when determining the most appropriate control strategy. These include cell size, density, proximity to water, timing, presence of desirable plant species, habitat value, presence of wildlife, presence of SAR, human activity, available funds, ownership, and long term management plans. For small areas, with low to medium density, mechanical control may be feasible. Larger areas of infestation can only be effectively controlled using herbicides. For dense, mature cells, *Phragmites* control efficacy is greatly enhanced when both herbicide and fire are combined.

Timing herbicide applications to occur when no water is present has allowed for some seasonally wet sites to be sprayed. However, for coastal wetlands, the timing window for dewatered conditions can be rather short and can change year to year. Usually even with dewatered conditions interspersed wet areas will usually remain, making effective, efficient and environmentally responsible control very difficult. There are also sites that just cannot be accessed from the ground using the equipment currently available and these areas require control via aerial application.

Other challenges to control efforts include the fact that there is no overall strategy in place for the province. *Phragmites* is now spreading into Northern Ontario and so far is mostly confined to relatively small cells along the edges of roads and boat launches. These cells can easily be controlled but there is no program in place to ensure this happens in a timely fashion. In many cases *Phragmites* is not recognized as a threat until it has become well established and far more difficult to deal with. *Phragmites* is being spread into the north and throughout the interior of the province mainly through the movement of heavy equipment between construction sites, which transports plant material from a contaminated

site to a clean site. These spread vectors can easily be reduced but no program is currently in place to ensure equipment is cleaned after leaving each work site. Increased use of ATVs in sensitive coastal and interior habitats has also been spreading *Phragmites*. Education about the negative effects ATVs have on sensitive habitats, and in some cases access restrictions, would reduce this damaging activity and spread vector. As well, there are a number of very large, Provincially Significant Coastal Wetlands that have *Phragmites* cells established throughout which are currently not being managed. This is either due to the exorbitant cost associated with control, lack of effective tools, lack of knowledge regarding the threat, or a combination of factors. In some cases, it is also due to confusion regarding land ownership along the Great Lakes coastlines, where exposed shorelines and wetlands that have developed due to declining water levels have effectively become 'orphaned habitats'. Additional challenges in *Phragmites* management result from the fact that 100% mortality is rarely achieved after one treatment. Having funds and a plan in place to undertake follow-up efforts to deal with the surviving plants, is critical. Otherwise, the initial time and money invested will be wasted. Control costs and effort will reduce substantially in the years following these initial efforts but in many cases these long term programs have not been instituted.

#### ***Phragmites* Initiatives**

A number of *Phragmites* control initiatives are being undertaken throughout the province (Fig. 6). These projects vary in scale from small shoreline cells to hundreds of acres of coastal habitat. *Phragmites* control along roadside ditches is also on the increase within some areas of Southern Ontario as are projects within towns and cities. Four of the larger-scale projects are occurring at Rondeau Provincial Park (Lake Erie), Kettle and Stony Point First Nation (Lake Huron), the Municipality of Lambton Shores (Lake Huron), and the Municipality of Kincardine (Lake Huron). Ecosystem response post control within some of the large coastal wetlands has been very positive (Fig. 7).

In December 2011, the Ontario *Phragmites* Working Group (OPWG) was established. This group is composed of dedicated people with an interest in working together to facilitate effective management of invasive *Phragmites* in Ontario. This initiative is aimed at reducing the current threats posed by this aggressive invasive plant to biodiversity and species at risk (SAR) through habitat protection and restoration. Specific goals focus on facilitation of education, information sharing, and investigation and pursuit of effective management options. In 2013 the OPWG officially became a subcommittee of the Ontario Invasive Plant Council (OIPC). Currently there are over 40 professionals involved with the OPWG including representatives from the Lambton Shores *Phragmites* Community Group, Ontario Parks, Nature Conservancy of Canada, Lake Huron Centre for Coastal Conservation, Carolinian Canada Coalition, private contractors and concerned private citizens, BASF, First Nations, Conservation Authorities, municipalities, Township of Huron-Kinloss, MNR, MOE, CWS, Environment Canada, Point Pelee National Park, City of Hamilton, Georgian Bay Forever, researchers, teachers, Communities in Bloom, Master Gardeners, Ontario Good Roads Association, and Ducks Unlimited Canada. The OPWG is also linked in with the Great Lakes *Phragmites* Collaborative which is a US based bi-national program. In collaboration with the OIPC and MNR a *Phragmites* information website is being developed for 2014. Other immediate goals include pursuit of action to control *Phragmites* in the northern portions of the Province before it spreads into adjacent wetlands and water courses, increasing public education, and advocating for overwater and aerial control options.

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## Understanding Reptile and Amphibian Trends in Relation to Changes in Wetlands: A Pilot in the Essex Region Watershed

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### Introduction

Amphibians and reptiles are declining world-wide. In fact, amphibians are the most at-risk vertebrate taxa globally with over 40 percent considered vulnerable to extinction (Secretariat of the Convention on Biological Diversity 2010). Similarly, 20 percent of reptiles are considered at risk of extinction globally (Böhm et al. 2013). In Ontario, the most recent amphibian and reptile data suggests significant declines in geographic range, with roughly one-quarter of the species showing declines of 50 percent or more within this geographic area (Ontario Nature 2012). One of the main reasons for the spatial declines is due to both historical and present day habitat loss. In addition, road mortality, changes in climate and weather patterns, environmental pollution, and vulnerability to diseases also play a role in the decline of amphibians and reptiles.

The most significant impact on amphibian and reptile populations is due to loss of wetland habitats. For example, the loss of original or pre-settlement (c.1800) wetlands is estimated to be 72 percent in southern Ontario (Ducks Unlimited Canada 2010). While the wetland loss was quite dramatic at the time of European settlement in southern Ontario, it still continues.

Coupled with wetland loss, fragmentation and impacts of surrounding land uses also put pressure not only on wetland specialists, but also on the many semiaquatic species that rely on wetlands during some stage in their life history. The remnant wetland cover is often fragmented and dispersed across the landscape, surrounded by different land uses, and across public, private and conservation-owned lands. The resources required to inventory and monitor these areas to

detect changes in amphibian and reptile populations are beyond capacity of most conservation groups in Ontario. However, by engaging the public in reporting their observations through a citizen science program will enable conservation organizations to collect relevant species data across a broader landscape, to monitor the state of amphibians and reptiles in Ontario.

Citizen scientists create a unique partnership between volunteers and scientists which enable not just the building of evidence, but also provide the ability to answer real world questions. Although the term citizen scientist is relatively new, the practice of public engagement in monitoring dates back to the 1900s with the first Christmas bird count by the National Audubon Society (Cohn 2008). Through data collection and monitoring initiatives, citizen scientists contribute to conservation efforts and provide valuable information that supports science and research, but also inform decision making and policies.

In the last five years, Ontario Nature has increased the knowledgebase base of amphibians and reptiles in Ontario through a citizen science program -- the Ontario Reptile and Amphibian Atlas (ORAA). Ontario was the first region in North America to start an amphibian and reptile atlas in 1984, called the Ontario Herpetofaunal Summary (OHS). Atlas efforts have since continued as the Ontario's Reptile and Amphibian Atlas program at Ontario Nature. To date the ORAA and OHS houses over 350,000 observation records. Data collected over the span of both atlases suggest spatial declines of amphibian and reptile species, with roughly 25 percent of the species showing declines of 50 percent or more.

In this study, we analyzed habitat and species occurrence data over time to determine the impact of habitat loss on the spatial distribution of the amphibians and reptiles in Ontario.

### **Methods**

For the study, Essex Region watershed was used as a pilot study to examine if wetland habitat changes in this area are contributing to spatial declines in wetland-dependent amphibians and reptiles. We compared changes in wetlands to the historic and current distributions of species that use wetlands for all or part of their life history. Two different data sets were used: the Ontario Nature Ontario Reptile and Amphibian Atlas (2012) and the Ducks Unlimited Canada wetland conversion analysis (2010).

Amphibian and reptile data are collected through a variety of means. Efforts to map spatial distributions of amphibians and reptiles in Ontario rely heavily on data submitted by citizen scientists. Data are collected through both intentional and incidental sightings. The data set also includes feeder data sets coming from groups such as: Natural Heritage Information Centre (Ontario Ministry of Natural Resources), Marsh Monitoring Program (Bird Studies Canada), Backyard Frogs (formerly Environment Canada, now Ontario Nature), Carolinian Reptiles (Long Point Basin Land Trust), Adopt a Pond and Turtle Tally (both Toronto Zoo), as well as data from numerous masters and doctoral research projects. The data used for this analysis span over 100 years with historic observations dating back to the late 1880s ranging to the latest observations from 2012.

We examined data to determine if a species was present during each of four timeframes. Areas where wetlands changed in size or presence during the timeframe was compared against areas where wetlands were relatively consistent through time. A proximity analysis was conducted for each of the four time periods, where wetland polygons were compared to species observations within 200 metres (a distance relatively easy to travel for most amphibians and reptiles). The wetland conversion data set provided a snapshot

of wetland habitats during four different time periods [pre-settlement (circa 1800), 1967, 1982 and 2002]. Methods to create this data set are outlined in the DUC (2010) document. A spatial comparison was made for the four time- periods for species that use wetlands for a majority of their life cycle.

A second analysis was conducted in three focus areas to examine the trends in species observations. We focused in three areas in the Essex Region with varying levels of wetland change, policy protection and species observations: Point Pelee National Park, Hillman Marsh Conservation Area, and a private area with road access and protection only under the Provincial Policy Statement referred to as the Detroit River Marshes (i.e. not in conservation ownership). Within each of these areas the targeted species had a variety of levels of data and contributors (Table 1). Data were graphed for each focus area comparing the abundance of wetland-dependent species for each decade.

### **Results**

Exploratory analysis of the amphibian and reptile data set in the Essex Region shows that observations vary over time, but average around 200 observations per year after 1990. Observations of wetland-dependent species have seen a general decline since 1995. The period between 1995 and 2000 coincides with the loss of a Parks Canada staff member, who was a large contributor to the data set, as well as declines in provincial funding (Fig. 1). Recent years have seen an increase in both the number of volunteers in the area and the amount of funding for stewardship projects (due both the federal and provincial government sources such as the Habitat Stewardship Program and the Species at Risk Stewardship Fund).

Spatial analysis for Essex Region highlighted a few areas where loss of wetlands coincide both spatially and temporally with the absence of species data. However, most areas still show at least the presence of species, especially through frog-call data.

Species abundance profiles varied between all three focus areas with declines in most frog species. Point Pelee National Park (Fig. 2) showed declines in all species except Western Chorus Frog, for which observation data stayed relatively stable over the 60 year time-frame. Hillman Marsh Conservation Area (Fig. 3) showed a decline in all frog species with the exception of Leopard Frog, which showed an increase in the number of observations. The Detroit River Marshes (Fig. 4) showed declines in all species observations with the exception of American Toad, which showed a marked increase.

**Discussion**

The results of this analysis demonstrate the power of long-term volunteer data sets to indicate changes and potential decline of species. For example, the pilot study of the Essex Region watershed indicates the potential local decline in frog abundance. While the declines in number of specific species varied among different sites, they are still consistent with the overall declining trend seen in the data.

The number of observations in the composite datasets encompassed a variety of data collection methods (i.e. incidental, short-term and long-term data sets). These data sets are not only influenced biologically (i.e. by the decline in a species), but are also influenced politically (i.e. by the funds and programs that were available over the year and areas targeted for sampling). Regardless, this analysis of the composite data sets can serve to outline potential areas that can be targeted further for site-specific investigation.

While our analysis shows that in some cases, cause of declines can be linked to wetland loss, the data strongly suggests that it is not the only cause of observation declines. The analysis further supports the case for a citizen science program that is independent of political funding and can cover large geographic areas.

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Table 1. Data collection at three Provincially Significant Wetlands in Essex County.

Area	Policy/ Conservation Ownership	Year of conservation ownership	Monitoring
Point Pelee National Park	Parks Canada	1918	Parks Canada staff Research projects (including MSc and PhD) Marsh Monitoring Program Visitors
Hillman Marsh Conservation Area	Conservation Authority	Early 1980s	Conservation Authority staff Visitors Marsh Monitoring Program Backyard Frog
Detroit River Marshes	Provincial Policy Statement	1985	Marsh Monitoring Program Backyard Frog Incidental

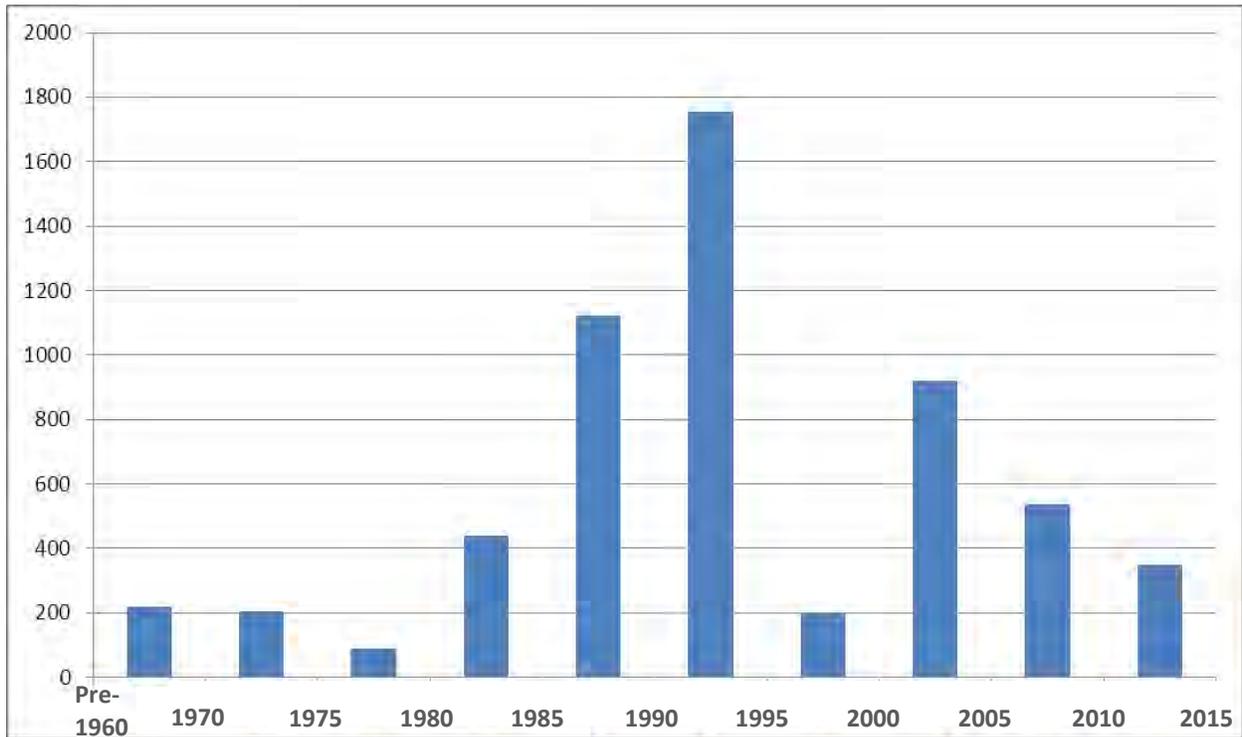


Figure 1. Wetland-dependent amphibian and reptile observations in Essex Region watershed.

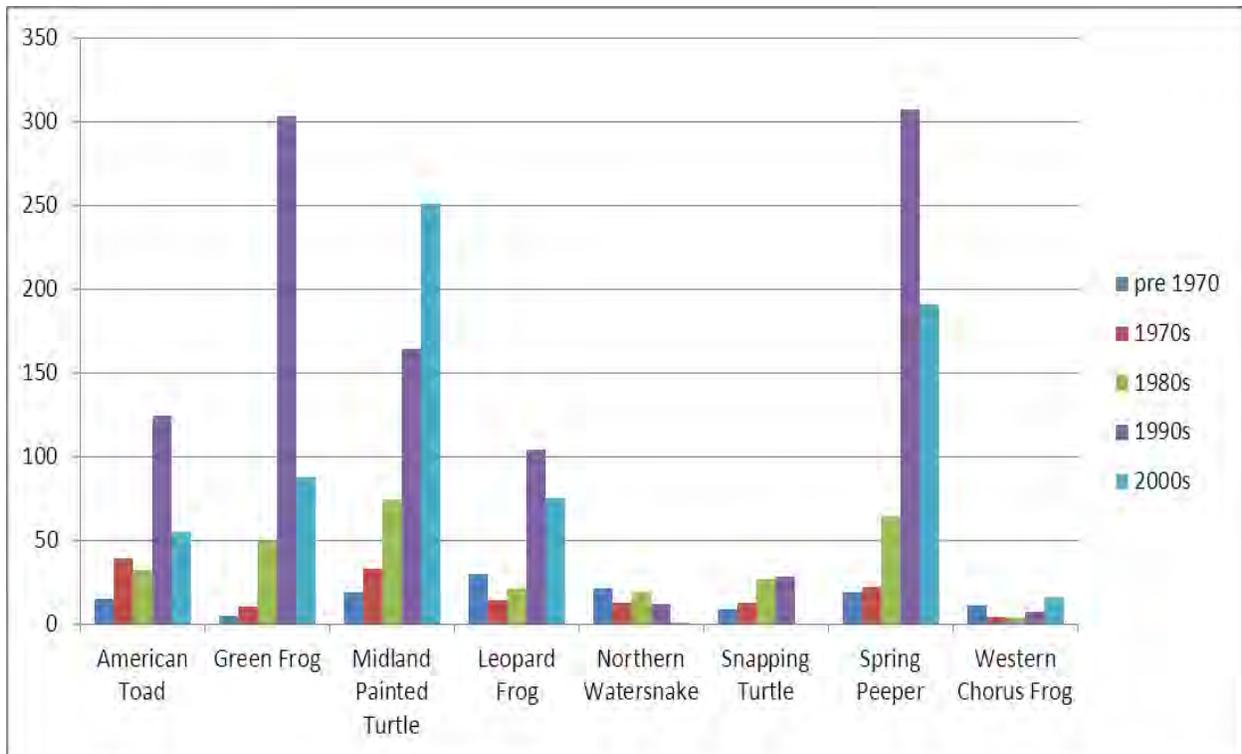


Figure 2. Point Pelee National Park wetland-dependent amphibian and reptile observations by decade.

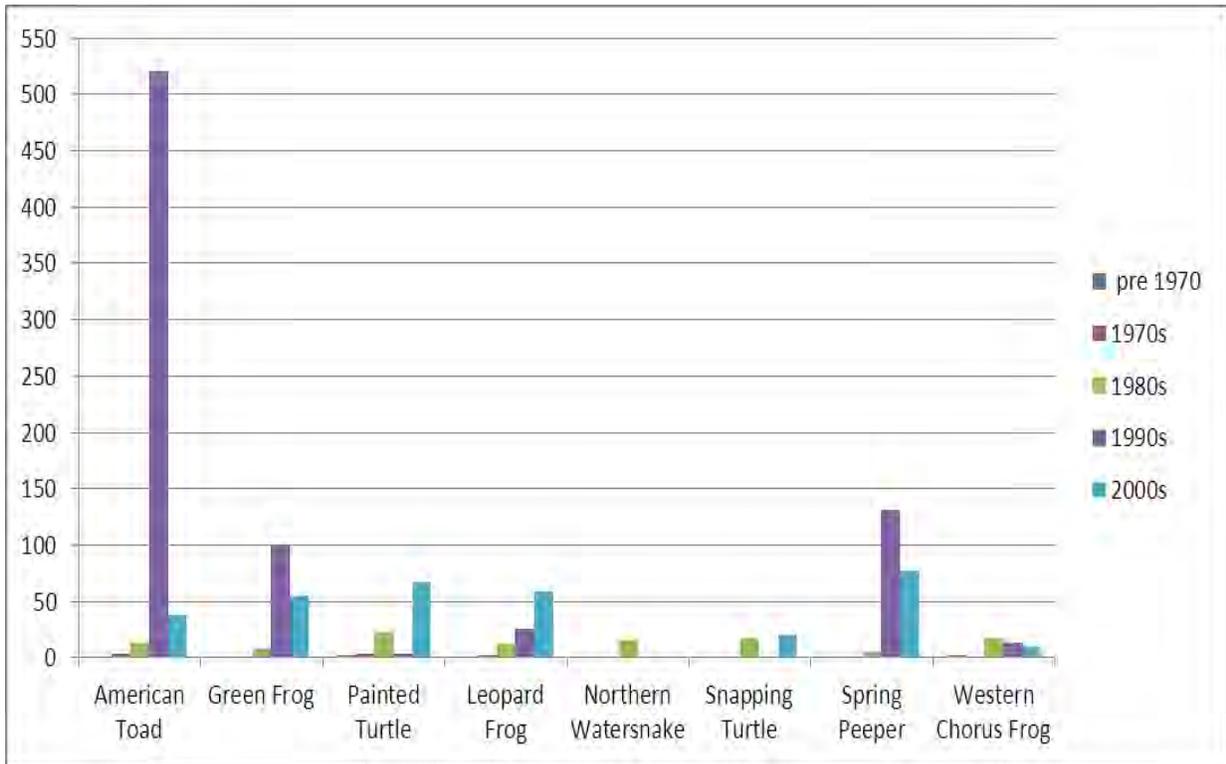


Figure 3. Hillman Marshes Conservation Area wetland-dependent amphibian and reptile observations by decade.

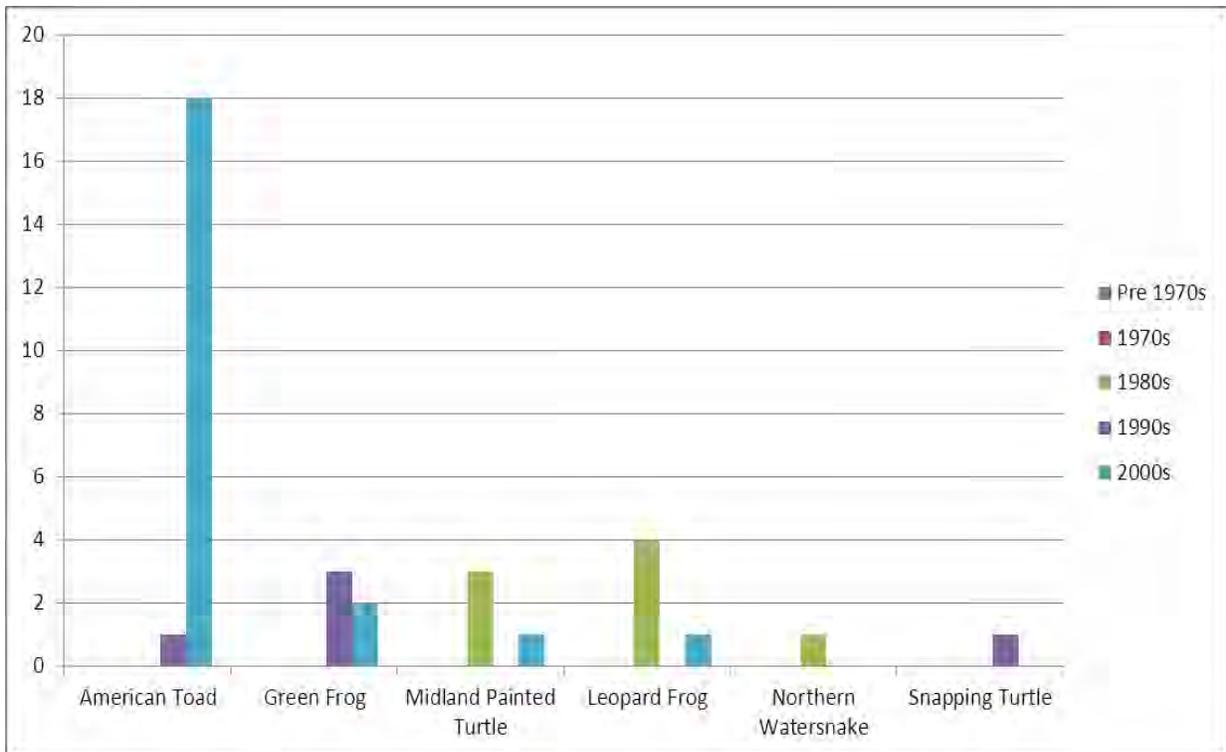


Figure 4. Detroit River marshes wetland-dependent amphibian and reptile observations by decade.

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## Predicting Coastal Wetland Restoration Outcomes Using State-and-Transition Simulation Models: A Case Study for Point Pelee National Park

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### Introduction

Invasive species are one of the biggest threats to the ecological integrity of Great Lakes coastal wetlands. The spread and dominance of cattails (*Typha* spp.) into wetlands has occurred around the world in response to various natural and anthropogenic perturbations (e.g. nutrient enrichment, altered hydroperiod/water levels, altered sedimentation rates, non-native genotype introductions) (e.g. Galatowitsch et al. 1999, Zedler and Kercher 2004). Over the past decade, *Phragmites australis*, a tall perennial grass indigenous to North America, has rapidly spread in eastern North America, likely resulting from the introduction of a more aggressive European genotype (Saltonstall 2002). Similar to cattails, *Phragmites* forms dense, monospecific stands that reduce biodiversity, alter habitats, hydrology and nutrient dynamics in wetlands with negative consequences on biodiversity (e.g. Chambers et al. 1999).

Point Pelee National Park is a sandspit formation which extends into the western basin of Lake Erie that encompasses a large (1113 ha), barrier-beach type coastal wetland which was designated a RAMSAR wetland in 1987. Similar to other Great Lakes coastal wetlands, the wetland in Point Pelee has been subject to landscape-scale changes in vegetation due to the expansion of cattails and *Phragmites*. Cattails are the dominant feature of Pelee marsh, and their spread has altered the habitat mosaic of the wetland. Over the past decade, *Phragmites* has spread in the park, colonizing *Typha*-dominated areas and further threatening marsh biodiversity, wildlife habitats, and functions.

Improving the ecological integrity of the wetland will require actions on the ground aimed at controlling the spread of *Phragmites* and restoring a mosaic of habitats in the marsh. Restoration is however costly, so being able to determine which actions are most effective in the long-term, and which actions will be resilient over time before initiating any restoration, is ideal. State-and-Transition Simulation Models (STSMs) use a Markov chain approach to predict changes in vegetation over time in response to natural disturbances and management (Daniel and Frid 2012); these models have been used previously to plan for the restoration and the management of invasive species (e.g. Provencher et al. 2007, Frid and Wilmschurst 2009), including a wetland application in the Florida Everglades (Zweig and Kitchens 2009).

The objective of this study is to develop an STSM for *Typha* and *Phragmites* dynamics in coastal wetlands, using data from Point Pelee National Park. The model will then be used to compare the outcomes and costs of various management scenarios, including mechanical, chemical and hydrological control methods.

### Methods

We developed an STSM for the coastal wetland comprised of three main vegetation states: Open Water (or no emergent vegetation), *Typha*-dominated and *Phragmites*-dominated (Fig. 1). In wetlands, hydroperiod/water levels determine plant community composition and zonation, and greatly influence the dominance and resistance of cattails and other invasive wetland plants (Zedler and Kercher 2004). As such, we included elevation strata (by 0.5 m intervals) into the model to include the dynamics of variation in water depth

on the distribution of wetland vegetation. Based on historical and field data from the park, a large portion of the cattails in Point Pelee are floating mats, however, there is large uncertainty associated with the amount of floating versus rooted cattails. As a result we distinguished between these two types of growth forms in the model, in this way testing assumptions about the proportion of floating or rooted forms, and the effects of these assumptions on the outcomes of alternative management scenarios.

Changes in the cover of *Typha* and open water over a 50-year period were quantified through the classification of aerial imagery (images for 1959, 1977, 2004, 2010; 1:4000-1:10000; panchromatic or colour (RGB)) taken in April of each year. The resolution of all maps was adjusted to 1m. Classifications were completed using object-based image analysis based on scale, spectral information, smoothness and compactness into open water and cattail, and validated using historical and field data from the park. In April, the submerged and floating macrophytes are not yet present or visible in the imagery, so the open water state represents a larger mosaic of wetland habitats; for modeling purposes, however, we limited our analyses to emergent vegetation

dynamics. Park field data also show that *Typha* are not complete monocultures, and within areas dominated by *Typha* there is a diversity of other emergent species intermingled (10-15%); however, at the scale of the landscape these are grouped in with *Typha* and we did not attempt to discriminate emergent species to a finer scale. *Phragmites* cover was assessed from the 2004 and 2010 imagery, validated with ground truth data collected in 2007-2009.

Habitat maps derived for each year were superimposed onto a numerical elevation model of the wetland in 0.5 m intervals (Keitel unpublished data), to obtain a classification for each state (open water, *Typha*, *Phragmites*) by elevation stratum. For the STSM, rates of cattail expansion or encroachment or invasion by *Phragmites* were calculated based on changes in area between two time periods, and converted to transition probabilities using the following equation:

Annual Transition Probability =

$$1 - \left( \frac{\text{Area } T_1}{\text{Area } T_0} \right)^{\left( \frac{1}{T_1 - T_0} \right)}$$

Where  $T_0$  and  $T_1$  represent the years in which the area was determined.

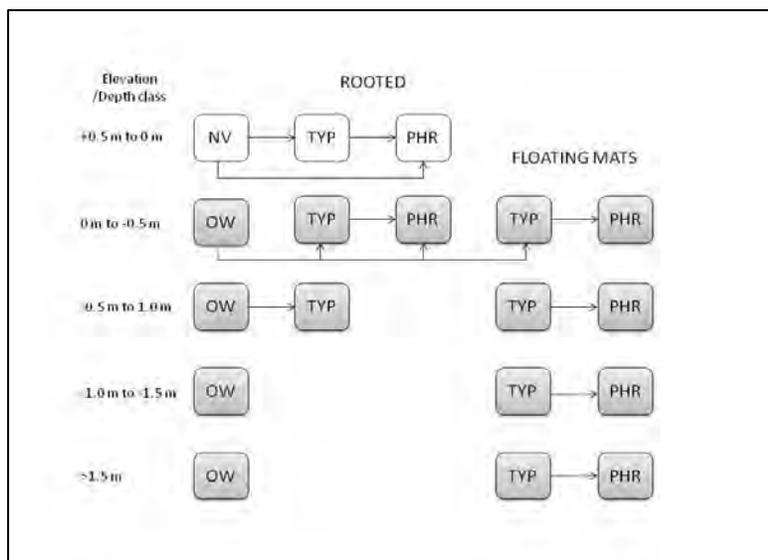


Figure 1. State-and-Transition Simulation Model for natural wetland dynamics in Point Pelee National Park. Boxes represent vegetation states while arrows represent possible invasion transitions between states. NV is no vegetation, OW is open water, TYP is *Typha* spp., and PHR is *Phragmites*.

Rates of cattail encroachment were calculated using changes in the area of open water between 1959 and 2004 for each elevation stratum. Invasion rates for *Phragmites* were derived for the period between 2004-2009, for *Phragmites* invasion of both open water/no vegetation areas, and of *Typha* dominated areas. We assumed that invasion rates remained constant.

To this baseline model (Fig. 1), we then added transitions associated with three alternative management scenarios: 1) Mechanical control by dredging or using an aquatic plant harvester to remove all biomass; 2) Flooding (raise water level by 0.5m); and 3) Herbicide application,

Table 1. Summary of the cover of Open Water, *Typha* spp., and *Phragmites* based on classified images between 1959 and 2010. Mean monthly water levels (for April of each year - the month that images were acquired) were obtained from the Kingsville gauging station, Lake Erie.

Year	Mean Water Level (m, IGLD85)	Area in ha (%)		
		Open Water (no vegetation)	<i>Typha</i> spp	<i>Phragmites</i>
1959	174.04	400.4 (40%)	613.9 (60%)	0.0 (0%)
1977	174.00	350.2 (35%)	664.2 (65%)	0.0 (0%)
2004	174.11	312.8 (31%)	691.6 (68%)	10.0 (1%)
2010	174.08	304.1 (30%)	680.9 (67%)	29.3 (3%)

**Results**

Since 1959, there has been a clear loss of open water habitats within the wetland and an expansion of cattails (Table 1, Fig. 2). In 1959, 40% of the wetland was open water, whereas by 2010 only 30% remained in this state. The cover of *Typha* increased over that same period of time, and in 2010, *Phragmites* covered 30 ha or roughly 3% of the marsh. It is the small (<1 ha) patches of open water that are most susceptible to colonization by *Typha*, leading to a slow in-filling of

spray/roll/burn combination used to control *Phragmites*. The effectiveness or success/failure of each method was estimated from information available from the park, from information available via the Great Lakes *Phragmites* collaborative (<http://greatlakesphragmites.net>), and from discussions with a practitioner (Gilbert, pers. comm.).

the marsh, and loss of diversity of a mosaic of habitats.

Changes in the area of open water were not directly attributable to changes in water levels in Lake Erie between years, as the hydrological conditions for the years used in the analyses did not differ considerably, with a maximum difference of 11 cm in levels between years assessed (Table 1).

When the areas of each state from 1959, and transition probabilities calculated for Point Pelee were input into the STSM, and the model run for 51 years (1959-2010), the output showed good correspondence with observed data (Fig. 3), with <30 ha differences between predicted values and the 2010 cover data.

**Discussion**

The expansion of cattails and more recent invasion by *Phragmites* threaten the ecological integrity of the Point Pelee marsh. Over the

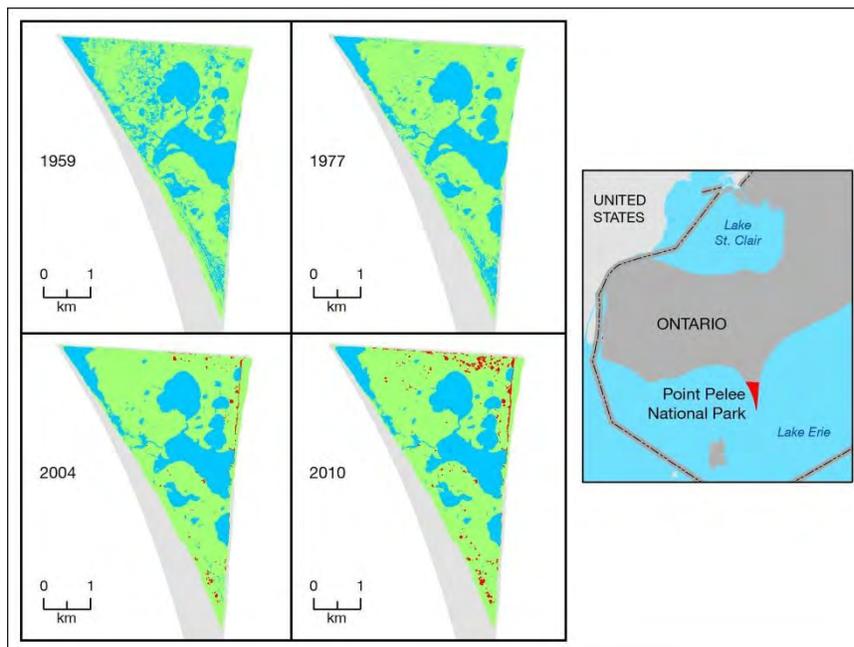


Figure 2. Wetland state classification for 1959 to 2010 in Point Pelee National Park based on spring aerial imagery. Blue represents open water (or no emergent vegetation), green *Typha*-dominated areas, and red *Phragmites*-dominated.

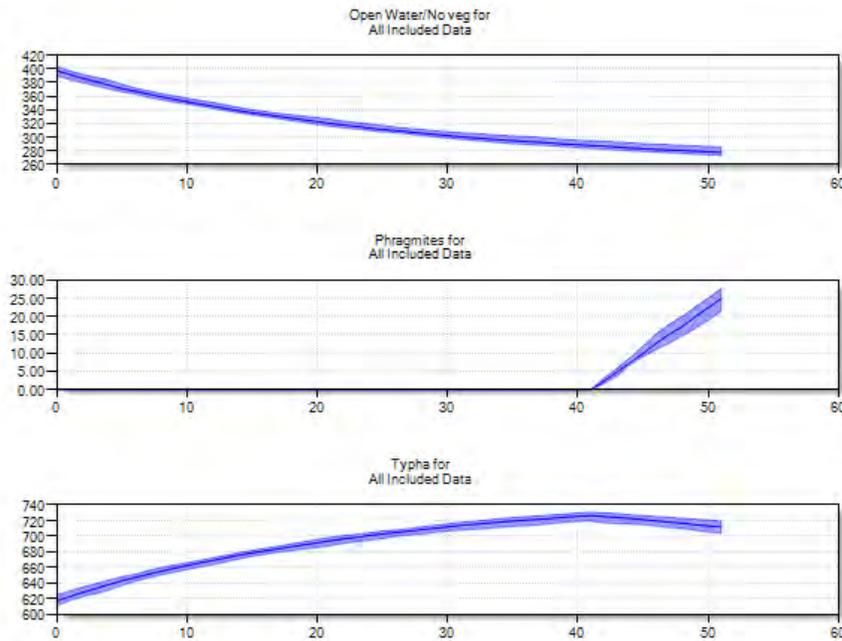


Figure 3. Predicted mean changes in each vegetation state (Open water, *Phragmites* and *Typha*) in the Point Pelee wetland based on State-and-Transition Simulation Model with the y-axis representing years, and 1 is the year 1959, and running for 51 years (until 2010). The blue band represents the minimum and maximum based on 100 Monte Carlo replicates.

last 50 years, the loss of the mosaic of small open water habitats to *Typha* represents changes in habitat diversity within the marsh. However, *Typha* (> 85%) are not complete monocultures compared to *Phragmites* (> 95% dominance per m<sup>2</sup>), so management strategies that tackle or control the *Phragmites*, with longer term goals of re-creating openings by reducing the dominance of cattails in the wetland would be optimal for the park to increase diversity and restore wetland ecosystem condition.

The outcomes of the alternative management scenarios were not yet available for this extended abstract, however, they will be reported on in the presentation, and in follow-up reports and publications of this work. Nonetheless, results of the model showed good correspondence with historical data, and indicate that the STSMs will be useful to compare the outcomes of various management methods, and combinations thereof to determine which management strategy has the best long-term outcome. Also, costs associated with each management scenario can be factored into the simulations to determine, given limited

resources, which efforts on the ground will have the most lasting impacts on increasing habitat diversity, and consequently maintaining or improving biodiversity.

A further use of the model will be to test the sensitivity of the management outcomes to various assumptions regarding proportions of floating mats vs. rooted vegetation. This in turn, can help the park prioritize monitoring, to improve the reliability of model predictions.

In short, STSMs are useful tools to plan for wetland restoration at the landscape level, in particular for examining coarse vegetation dynamics related to invasive species, and supporting

management decisions with regards to restoration.

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## Over 40 Years of Wetland Conservation and Partnerships in the Minesing Wetlands

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### Introduction

*History* – The Nature Conservancy of Canada (NCC) and Nottawasaga Valley Conservation Authority (NVCA) have been working in partnership since 1973 to conserve the Minesing Wetlands. The Minesing Wetlands is one of the most significant wetland systems in southern Ontario, covering 6,000 ha (15,000 acres). This wetland, the third largest in the southern portion of the province, supports extremely high biodiversity values as it is home to thousands of species of plants and animals, and includes globally rare vegetation communities, provincially rare wetland types, and many species at risk. The area has several natural heritage designations, including provincially significant life science Area of Natural and Scientific Interest, Provincially Significant Wetland (PSW) and is a Ramsar List of Wetlands of International Importance. In partnership, NCC and NVCA have conserved over 10,000 acres and have implemented stewardship through a variety of initiatives, including those guided by the 2009 Minesing Wetlands Property Management Plan, a document co-authored and co-implemented by the two organizations.

*Property Management Plan* (Kostuk and Ferguson 2009)– NVCA holds title to all land that has been conserved in the Minesing Wetlands, though every property transferred to them from NCC is subject to a landholding agreement which requires that a management plan be created to guide stewardship. Due to the significant amount of conservation land in Minesing and the fact that a number of actions are applicable across a variety of properties throughout this 15,000 acre area, one cohesive planning document was developed to deliver

stewardship action. In 2009 the first NCC-NVCA Minesing Wetlands Property Management Plan (PMP) was jointly created and has been implemented successfully between 2009 and 2014.

### Conservation Targets and Threats

Both conservation plans are based on the international Open Standards for conservation, which includes the identification of conservation targets, assessing target viability, ranking threats and developing strategies. Please see Table 1 and Table 2 for a list of conservation targets and their viability and threats and their rank for the Minesing Wetlands.

*Conservation Actions* – A total of 23 management actions were created as part of the 2009 Minesing Wetlands PMP. Key actions include:

#### 1) Complete Ecological Land Classification Mapping

Objective:

- Complete vegetation classification for entire Minesing Wetlands area to guide management planning

Outcome:

- NVCA took lead on effort using knowledge of long term staff very familiar with the area

Table 1. Minesing Wetlands PMP Conservation Targets.

Target	Current Viability
Mixed and Coniferous Swamp Forests	Very Good
Hackberry and Bur Oak Woodlands	Good
Marshes	Good
Open Fens	Good
Rivers, Streams and Creeks	Good
Deciduous Swamp Forests	Fair
Reptiles and Amphibians	Fair

- NCC picked up initiative in later years of PMP, focusing on areas identified as high priority for Ecological Land Classification (ELC)
- ELC will be fully mapped in 2014 and incorporated into 2014-2019 PMP planning

2) Develop Forestry Management Plan

Objective:

- Develop professional forestry management plan to incorporate into 2014 PMP actions to guide management of forest targets

Outcome:

- Scope of plan was too large and would likely not be worth the investment the applicability of its findings to work in Minesing
- Scope pared down to create a forest health plan for an area of the wetland that was recently disturbed (Fig. 1)
- Success of this plan and its recommendations will serve as a template to guide future actions around forestry work in the area in disturbed sites

3) Investigate Creating Additional Hiking Trails

Objective:

- Improve existing hiking trails and consider creating one or more new trails to improve visitor access to Minesing Wetlands

Outcome:

- NCC, working with NVCA and NCC Conservation Volunteers, created a new trail on NVCA property (“Mad River Trail”) which will contain educational signage to further educate the public on the significance of the wetlands (Fig. 2)

4) Implement Streambank Stabilization Initiatives

Objective:

- Stabilize banks of major area rivers (e.g. Nottawasaga River, Willow Creek) with live stakes and



Figure 1. Forest health plan monitoring plot (photo by NCC).

soil anchors to improve habitat, reduce erosion and accelerate succession of areas to shrubland and forest

Outcome:

- Successful annual action led by NVCA, with assistance from NCC and volunteer groups (Fig. 3 and 4)
- At least 500 m of streambank stabilized annually with 500 – 2000 live stakes; over 3 km of soil anchors installed by NCC, NVCA and volunteers

Table 2. Minesing Wetlands PMP Biodiversity Threats.

Threat	Rank
Recreational activities	High
Nutrient and pesticide runoff and sediment loading	High
Changes to hydrogeology including lowering water table	High
Aquatic and terrestrial invasive species	High
Road kills of sensitive reptile species	Medium
Municipal effluent	Medium
Illegal dumping	Medium
Incompatible forestry on adjacent lands	Medium
Overabundant mesopredators	Medium
Residential development in surrounding areas	Medium
Climate change leading to more frequent storm events	Medium
Problematic native species	Low
Expansion of croplands adjacent to protected areas	Low

*Conservation and Management*



Figure 2. NCC Conservation Volunteer works on clearing the Mad River Trail (photo by NCC).



Figure 3. NCC and NVCA staff and volunteer stabilize banks of the Mad River banks with soil anchors (photo by NCC).



Figure 4. NCC staff and volunteers with willow live stakes to be used in upcoming streambank stabilization initiative (photo by NCC).

5) Educate the Public on the Minesing Wetlands

Objective:

- Increase awareness of Minesing Wetlands

Outcome:

- New signage installed within wetlands to educate public
- Public events attended (e.g. Barrie Ecofest, Festival at the Fort, Paddlefest)
- Increased involvement with Friends of Minesing Wetlands outreach/education/volunteer group

6) Meet Regularly and Re-establish Minesing Wetlands Management Committee

Objective:

- Increase frequency of meetings/reporting between NCC and NVCA
- Revitalize the Minesing Wetlands Management Committee (group comprised of NCC, NVCA, external partners, landowners, etc.)

Outcome:

- NVCA and NCC in frequent contact around status of all actions, emerging issues and next steps
- Minesing Wetlands Management Committee revitalized – first meeting in October 2013, next meeting planned for spring 2014; group will provide input into 2014 PMP

*Next Steps* – By 2015, a new PMP will be created that will guide management for the coming 5 years. This plan will take an adaptive approach to reflect the successes, accomplishments, new information, challenges and shortcomings of the 2009 plan.

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## Hydrogeology and Wetlands

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### Introduction

The hydrogeologic setting of a wetland can range from having a minor influence to being the dominate condition/factor.

Wetlands can experience groundwater inflow conditions (discharge wetlands), groundwater outflow conditions (recharge wetlands), both conditions either seasonally (discharge during wet periods and recharge during drier periods) or simultaneously (discharge in one area and recharge in another).

The type of interaction a wetland has with the groundwater regime can strongly influence the character of the wetland, nutrients available and of course the hydroperiod.

### Discussion

*Groundwater-Water Table* – Knowing some key information regarding groundwater and the water table can help us understand better the hydrologic functions of a wetland. One of the first steps is to know where the water table is.

The groundwater table (water table) is commonly noted as being at the boundary between the unsaturated zone and the saturated zone (Fig. 1).

While this is generally accurate, and a suitable definition for most purposes, according to Freeze and Cherry, the water table is best defined as “the

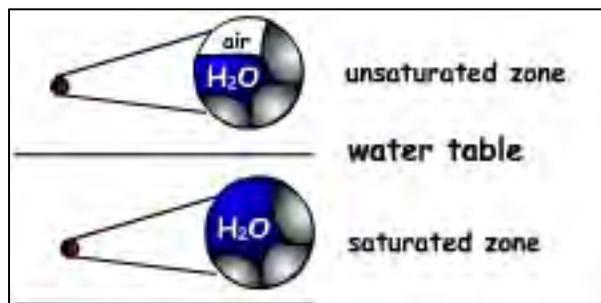


Figure 1. Diagram depicting the water table at the boundary between the saturated and unsaturated zones.

surface on which the fluid pressure  $p$  in the pores of a porous medium is exactly atmospheric”. In practical terms, this surface is the level at which water stands in a shallow well or pipe, open along its length, where the well or pipe penetrates the surficial deposits just deeply enough to encounter standing water in the bottom.

Groundwater is stored in the spaces between grains of silt/sand/gravel/etc. in overburden deposits and in fractures in igneous/metamorphic rocks and bedding planes/solution cavities/etc. in sedimentary rocks (Fig. 2).

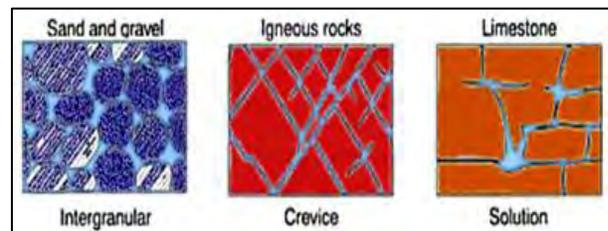


Figure 2. Main types of porosity. Where groundwater can be found. It fills the spaces between sand grains, in rock crevices, and in solution openings.

It becomes clear when examining the above diagram that groundwater only exists in the spaces in the material and not the material itself (with the exception of chemically bound water). For example, a well drilled into solid rock with no fractures would yield little or no water; interception of water bearing voids is essential in accessing groundwater resources.

*Groundwater-Movement* – Lateral and vertical groundwater movement is driven by pressure gradients. Much like heat moves through a media from high temperature to low temperature, groundwater moves from high pressure areas to low pressure areas. The pressure in the subsurface can be observed by noting how high groundwater moves up a solid pipe open only at the top and bottom ends (i.e. not along its length). The higher the water moves up the pipe,

the greater the pressure at depth. Thus, two pipes side by side (A and B below), open at the same depth display different water levels and therefore different pressures. In this example, groundwater pressure is higher in well A than in well B, therefore groundwater moves horizontally from A to B (Fig. 3).



Figure 3. Diagram depicting groundwater flow according to the pressure gradient.

The same analysis holds for vertical movement. If pressure at depth is greater than pressure at surface there will be a vertical component of groundwater flow upwards (and vice versa) provided there are no blockages (confining units) and that the media is suitable for groundwater movement (for example dense tills may exhibit a pressure gradient but due to the character of the till, groundwater won't readily move).

The movement of groundwater is a determining factor which would decide whether a wetland has a discharge or a recharge component to it. Groundwater moving toward and discharging into a wetland would be a wetland discharge scenario; groundwater moving out of a wetland into the subsurface (towards the water table) would be a wetland recharge scenario.

*Wetland Settings* – There are three basic hydrological settings that can be considered for wetlands as well as combinations of these three settings (Fig. 4). The three basic settings are:

1. **Recharge:** Surface water and precipitation collected in the wetland migrates vertically (flows out of) the wetland and downwards into the groundwater regime *recharging* the water table. These wetland types occur when the surface water elevation in the wetland is higher than the groundwater elevation.
2. **Discharge:** Groundwater discharges (flows into) the wetland because the water table adjacent to the wetland is at a higher elevation than the surface water in the wetland. This elevation difference (and hence groundwater pressure difference) allows the groundwater to migrate into the wetland. The wetland in this setting could have either an overland outlet or no outlet at all.

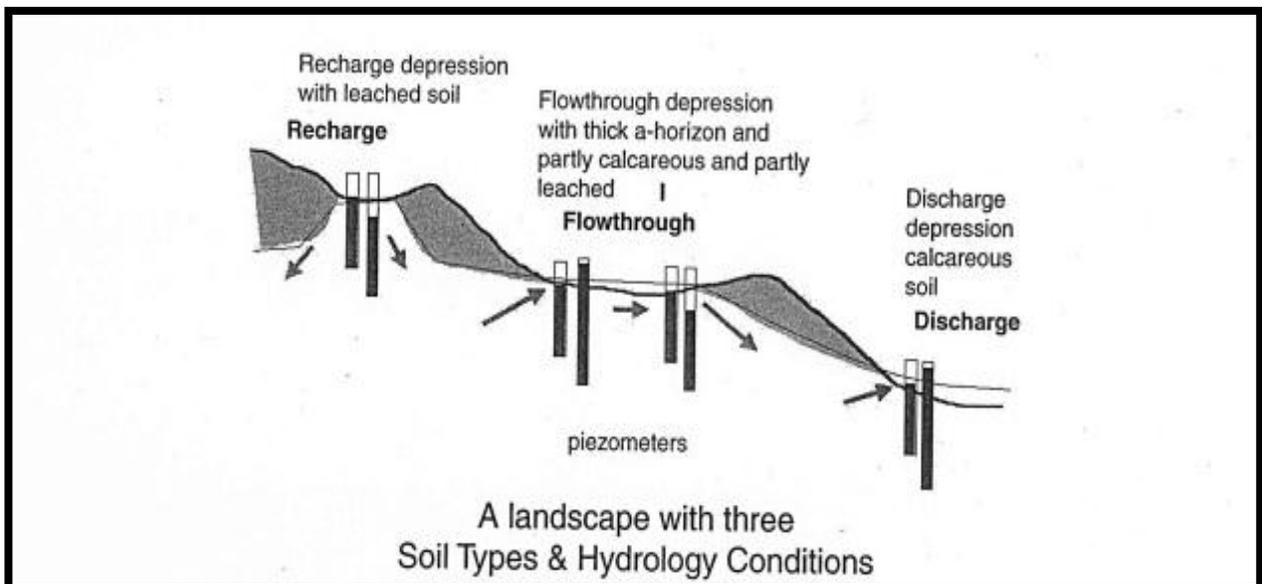


Figure 4. Three basic wetland/hydrology settings.

## *Conservation and Management*

3. **Flowthrough:** Groundwater enters the wetland under a discharge condition in one zone of the wetland and leaves the wetland under a recharge condition in another zone of the wetland. These wetlands can be the result of a sloped topographic setting which creates a groundwater flow system that gets intercepted by the wetland allowing water to flow through the wetland.

There is also the special case of a *Perched Wetland Condition*. In this case the above scenarios are suspended above the regional water table by a low permeability layer (e.g. clayey till). The low permeable layer inhibits downward groundwater flow to the regional groundwater table and in the process creates a perched water table condition (much like a saucer holding water on a table). This condition can then allow the perched water table to interact with wetlands but is often within a limited areal extent.

By understanding the hydrologic conditions that define a wetland we can better understand wetland function on the landscape. This understanding will hopefully lead to increased preservation of existing wetlands and rehabilitation of wetlands under threat.

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## Does the Ontario *Drainage Act* have Application in Wetland Management/Rehabilitation?

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### Introduction

Undertaking rehabilitation, enhancement and the restoration of Ontario's watercourses using the *Drainage Act*, with assistance of the Drainage investment Group (DIG) and its initiatives, can provide a societal benefit as well as improve the value and benefit of municipal drain projects as a whole.

The fundamental goal of the DIG is to incorporate features that will provide environmental enhancements, improvement to habitat and better water management along municipal drains. Features that may be used in these applications will be included in an engineering report which will help to protect and offer feature longevity through the *Drainage Act*.

DIG works collaboratively with funding partners to include these features as part of the municipal drain report, thereby offsetting the related costs to the landowners who are normally assessed the costs of the local drainage works as these improvements provide a much greater societal benefit.

DIG also works closely with educational institutions, environmental associations and various levels of government to provide science based programs, to research innovative environmental design elements and determine cost effective solutions to water quality issues.

Similar at first to Environmental Stewardship Programs, the DIG initiative will have the added impact of design elements being protected with the use of the *Drainage Act*.

A very powerful tool to be considered in wetland management or rehabilitation that should be considered for what it can accomplish moving forward.

### What does this all mean?

The term "drainage works" as defined by the *Drainage Act* (Ontario Government 1990) includes:

- A drain constructed *by any means*
- Including the *improving* of a natural watercourse
- And includes works necessary to *regulate* the *water table or water level within or on any lands*
- Or to *regulate* the level of the *waters of a drain, reservoir, lake or pond*
- And *includes a dam, embankment, wall, protective works* or any combination thereof

### Methods

By implementing water control structures (WCS), buffers and natural channel designs, among other options dependent on the landscape without impacting the immediate stakeholders when this is a societal benefit.

Features that work on many landscapes include:

- Water control structures
- Buffer zones and light barriers
- Natural channel design
- Erosion control
- Watercourse rehabilitation
- Aquatic and terrestrial habitat rehabilitation and enhancement

### Results

WCS help by restoring wetlands without impacting the lands requiring drainage. Strategically placed buffers are intrinsic in reducing the energy of the water which results in the trapping of sediment before it enters a watercourse. Natural channel design using natural

## *Conservation and Management*

and indigenous materials for such features creates long term habitat and reduces impact to species on the drain by reducing frequency of maintenance.

### **Key Factors and Practical Considerations**

- Examine current land use along the reach of the drain/tiled system
- Not all features work in all systems
- Changes or improvements to a drain will require a new engineering report
- Features are only protected if they are written into the engineering report
- The *Drainage Act* functions as a “user pay” system whereby the landowners contributing to or benefiting from the drainage system help to pay for its construction and maintenance. What is the societal benefit of environmental enhancements? How should the cost of environmental enhancements be recovered?
- Implementation of any enhancement is landscape dependent, but in the long-term provides feature longevity through its legal status under the *Drainage Act*, increasing species/habitant survival

*Moving forward, let's think creatively by:*

- Re-evaluating project scope and timelines; finding efficiencies and innovation all while protecting/creating Ontario's wetlands utilizing a longstanding and robust piece of provincial legislation
- Fostering positive relationships across all agencies and landowners/stakeholders alike
- Achieve and maintain positive public perception

### **Literature Cited**

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## Does the Ontario Drainage Act have Application in Wetland Management/Rehabilitation?

Brendan Jacobs

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### Introduction

As the name implies, Alternative Land Use Services (ALUS), approaches conservation in a manner that differs from that of many established conservation programs by recognizing that private landowners are the key to conservation and that these landowners are playing a huge role in shaping the landscape within our watersheds. The ALUS concept and vision is a simple one: to “create a healthy landscape that sustains agriculture, wildlife, and natural spaces for all Canadians” and was brought to fruition by Keystone Agricultural Producers (KAP) and Delta Waterfowl Foundation (DWF) in 2006.

ALUS is a community based, farmer-led and delivered program that works with local farmers and ranchers to increase nature’s benefits (clean air/water, biodiversity, habitat for fish and wildlife, and outdoor recreation opportunities) on their lands through the retirement of marginal and fragile areas. These areas are then reverted back to a natural state such as native tree/shrub cover, grass land, wetland, and buffer, just to name a few. In return, the landowner receives the environmental benefits that these natural features provide as well as an annual payment per acre enrolled in the program from ALUS. When added together, the cumulative benefits of these projects to the watershed and surrounding community have the potential to be extensive. Between 2006 and 2008, the first ALUS pilot project in Blanchard, Manitoba enrolled 70% of local landowners; half of whom had never participated previously in any conservation programs. For more in depth information on ALUS please visit our website ([www.alus.ca](http://www.alus.ca)).

Ontario East Alternative Land Use Services (ALUS) is one of four Ontario-based pilot project areas established in 2012. Ontario East ALUS operates within the United Counties of Stormont, Dundas

and Glengarry, the United Counties of Prescott and Russell, the City of Cornwall, the Municipality of Hawkesbury, and a portion of the City of Ottawa. These communities fall within the watersheds of two local Conservation Authorities: Raisin Region and South Nation. Currently, the Partnership Advisory Committee, which oversees the activities of Ontario East ALUS, is comprised of 15 members. Seven of these members are local farmers while the other eight members are representatives from local conservation organizations. Only the farmers have a vote when it comes to the direction of the program and how the program is rolled out within the local community. The role of the remaining eight members is an advisory one where they provide expertise and advice when needed on projects, funding proposals, and partnership development.

### Benefits of the ALUS Program

There are several overall benefits that the ALUS program provides. The first benefit being the creation of real and sustainable landscape improvements without the need for costly regulations. Within this statement, *costly* can refer to either a monetary value or a social value. Monetarily, regulations are not only costly to develop and implement but also there is the ongoing cost to monitor, enforce, and prosecute offenders – many of which end up getting off on technicalities even if they are caught contravening the law. If we look at today’s state of affairs, the status quo seems to be leaning towards less enforcement or the watering down of regulations, making what’s left potentially ineffective. Socially, regulations can have both a negative effect, when it comes to the public’s perception of those in the conservation field, as well as on the environment itself. When pushed through, environmental regulations can have an effect opposite to what

was intended, such as the clearing of woodlots or the draining and filling of wetlands.

The second overall benefit of the ALUS program is that it recognizes the role that farmers and ranchers play in conserving, protecting, and restoring natural features on their lands. Through ALUS, landowners are given a greater voice when it comes to developing and establishing conservation projects across the landscape. These actions, coupled with media coverage and tours of demonstration sites, leads to a shift in the public's perception and a bridging of the urban-rural gap when it comes to pointing fingers as to who is to blame for decreasing environmental conditions within a watershed. By bringing both sides together through ALUS, a community-based organization, we are able to increase the overall health of a watershed over time.

The two previously mentioned benefits allow for a greater conservation of natural resources and thus an increase in nature's benefits over time, such as increased water held on the landscape, reduced erosion and nutrient loading, increased habitat diversity leading to increases in biodiversity, conservation of species or species groups through habitat enhancements (e.g. pollinators), and aesthetics. The benefits gained through these projects positively impact not only the farmer, but the local community as well. Through their involvement with ALUS, landowners also receive the benefit of increased income opportunities from such things as alternative crops (nuts, berries, timber), but also income from recreation opportunities (e.g. hunting, fishing, birding, hiking, snowshoeing, and skiing).

The ALUS process is not prescriptive, which allows for greater flexibility when it comes to project design and establishment. A few of the general project types completed by Ontario East ALUS include the planting of native trees and/or shrubs (wildlife cover and food, shelterbelts, corridors, woodlot expansion), the establishment of buffers along waterways or surrounding wetlands (grasses and/or tree/shrub), pollinator habitat creation or enhancement to provide year round food sources and nesting habitat, habitat

structures (bird boxes, hen houses, turtle nesting/basking), and wetland restoration and enhancement.

### **Wetland Restoration and Enhancement**

Wetland creation from scratch can be an expensive and time consuming process and thus Ontario East ALUS tends to steer away from wetland creation and instead places it focus on wetland restoration and enhancement. In other words, Ontario East ALUS prefers to complete wetland projects in areas that historically or presently contain wetlands that have been degraded over time due to agricultural activities. Typically there are four wetland rehabilitation scenarios that Ontario East ALUS will take on. The first is in areas where the soils are saturated due to draws, a spring, or in a flood plain. In this case the restoration activity would be the creation of a pair-pond type project that would see the saturated soils excavated allowing for water to infiltrate into the pond and create open water habitat. Depending on site specifics, we are also looking at creating vernal pool as well as pit and mound type habitat in these areas. The second wetland scenario is the retirement of livestock watering ponds. This typically involves the fencing out of livestock and the creation of a buffer using native grasses and shrubs to provide cover. The third is the fencing out of livestock from wetlands or flood plains, allowing room for a buffer to be established between the fence and the wetland area. These sites are allowed to re-vegetate naturally as much of the natural vegetation and seed bank still exists. The fourth, slough restoration, tends to be the most costly as it involves the construction of dykes and the installation of water control structures.

Currently, Ontario East ALUS is working on five separate wetland projects: two pair-pond, one vernal pool, one pit and mound, and one slough restoration (see appendix for project diagrams, Fig. 1-9).

Wetland restoration and enhancement comes with many challenges that have a tendency to influence the process and the outcome of individual projects. They can be as simple as the

challenges surrounding site selection, landowner needs and or preferences and concerns, as well as on site characteristics and constraints (landscape issues: buildings, neighbours, roadways, upstream/downstream drainage...) to as complex as funding constraints and permitting. The everyday small scale challenges surrounding wetland projects are ones that can usually be worked through as one moves through the planning process. There will always be hiccups along the way but in the end the project most often gets completed on time and on budget. It is the larger issues that tend to disrupt the flow and put a bad taste in the mouths of those working towards restoring a wetland.

Funding constraints are nothing new in the realm of habitat enhancement where the greater the funds available the greater the project results can be (in terms of size and complexities). However, reality tends to be in the other direction where we are constantly trying to scrape together enough funds to complete small scale projects that will be of benefit on a local and watershed level. External funds are sought for such projects to ease budget concerns when it comes to constructions, however, there are even fewer dollars out there for pre and post construction monitoring which is what is needed in order to determine the overall success of wetland projects. Volunteers can help ease the burden but equipment is still needed depending on the type of sampling that should be completed.

In today's environment, permits seem to be everywhere you turn, which depending on how you view them may be a good or bad thing. Often these permits are designed for large scale development projects, industry, or activities that would impact the local environment in a negative fashion if not mitigated. In many cases however, the permitting process hinders small scale environmental restoration projects by adding undue costs, studies, delays, and frustrations where none should be. This on top of the fact that many of these projects could have easily been completed without the permits and no one would

have been the wiser. Permits maybe a necessity, even for small scale restoration works, but the process needs to be stream lined to better suit the needs of those working to restore or enhance wetlands – especially on a shoestring budget.

Appendix



Figure 1. Pre-construction air photo of pair-pond site, a headwater wetland.



Figure 2. Site plan for pair-pond construction.



Figure 3. Location of second pair-pond site with cattle access restriction and water system.

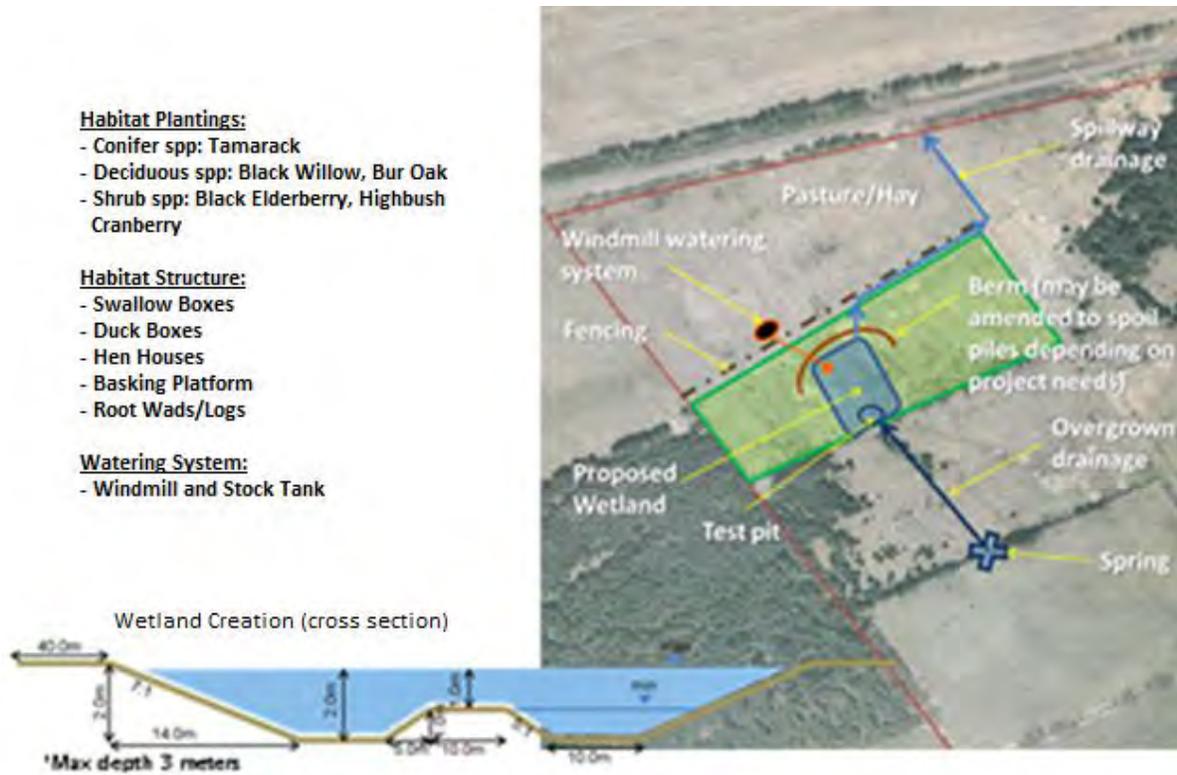


Figure 4. Site plan for pair-pond with cattle restriction and watering system.



Figure 5. Vernal pool project involves re-contouring a low section that tends to accumulate water in the spring and fall. Small berm, if necessary, to maintain water levels over a short period of time.

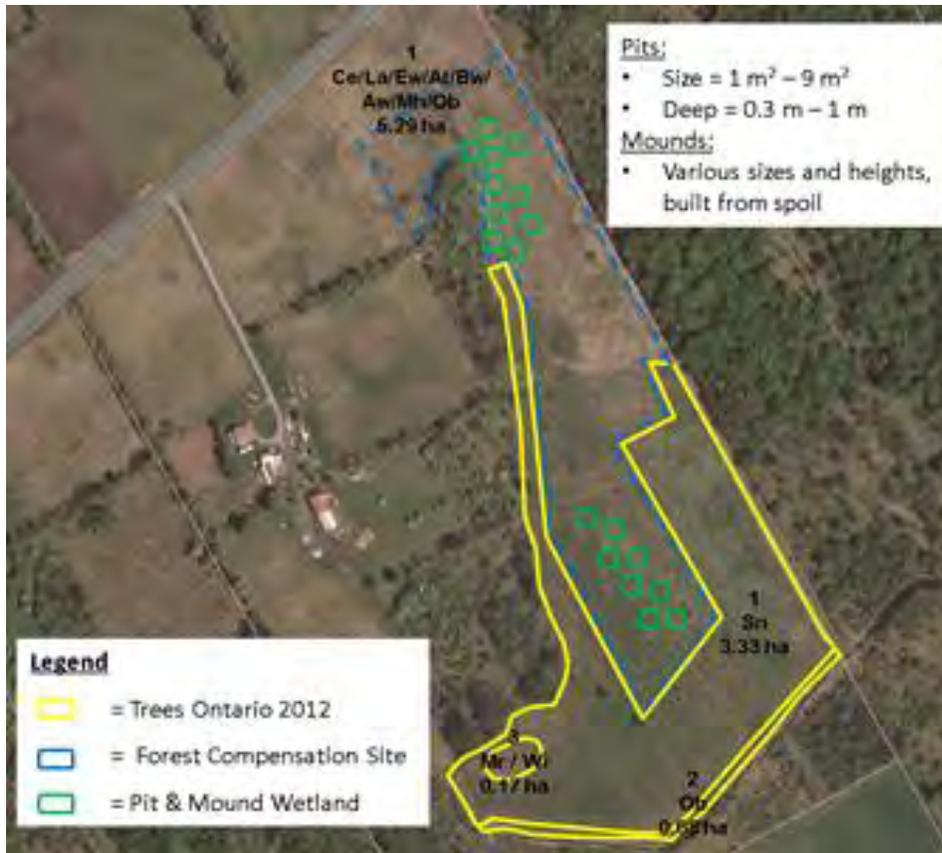


Figure 6. Pit and mound wetland project within a forest compensation area. Pit and mounds to be created in areas too wet to establish the desired tree species. The mounds will be planted with wildlife shrubs and/or willows.

## Sloughs (Drainage Restoration)



Figure 7. Location of the slough restoration project.



Figure 8. Pre-enhancement photo of the slough.

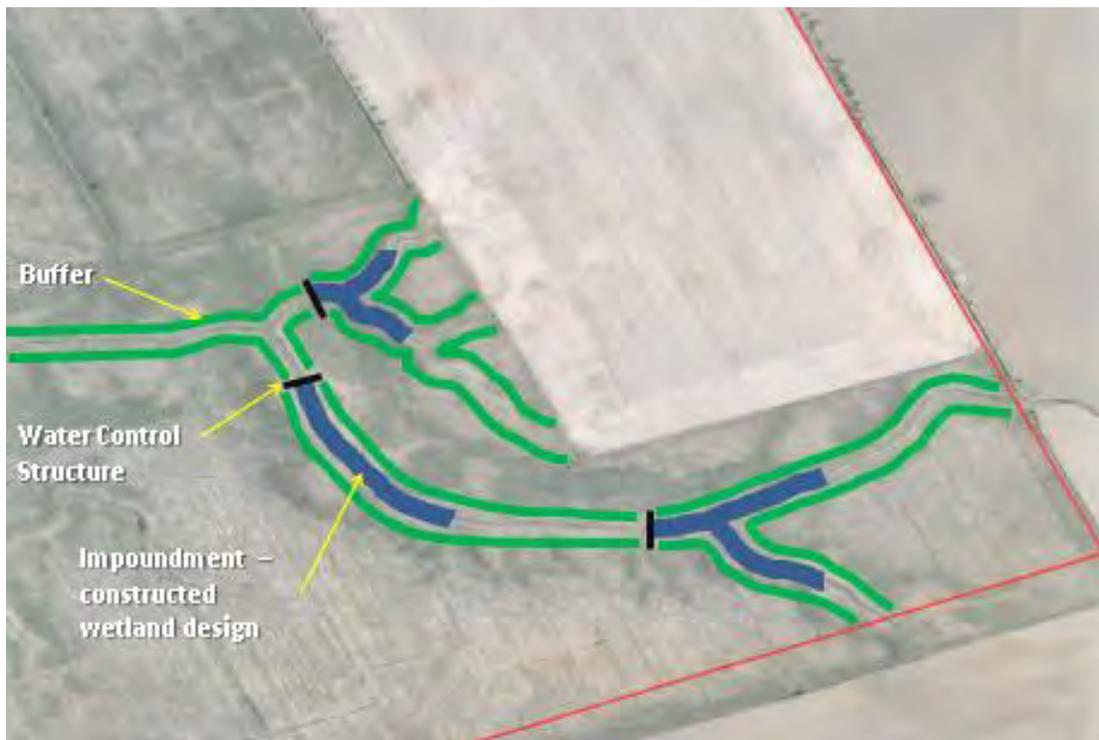


Figure 9. Slough restoration site plan. Buffer and setback for clops from the edge of the slough. The creation of three impoundments, using dykes and water control structures, to maintain water on the landscape and filter nutrients and sediments. Erosion control at tile outlets.

## Recreating Terrestrial Wetlands in Norfolk County

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### Introduction

Wetlands are an important part of the natural heritage of Norfolk County. They harbour many species at risk, support migratory birds and provide important ecological services to the community. They are also under heavy threat, and approximately 82% of the original wetlands in Haldimand and Norfolk counties have been lost (Ducks Unlimited Canada 2010)

The Nature Conservancy of Canada and partners developed a landscape conservation plan for the Southern Norfolk Sand Plains in 2008. This plan includes the conservation and restoration of inland and coastal wetlands. Inland wetlands are primarily found in the valleys of the upland forest areas. Inland wetlands contribute to the ecological and hydrological integrity of watersheds by augmenting the base flows of streams; moderating the erosive power of peak flows in streams; stabilizing stream banks and channels; reducing the overland transport of sediments and nutrients to streams; increasing the transit time of water flows within streams; and by absorbing and retaining nutrients, heavy metals and other contaminants.

Coastal wetlands are found along the shores of Lake Erie, and include the Long Point Marshes. They provide nursery and spawning habitat for game and non-game species of fish; staging and feeding areas for resident and migratory birds; and habitat for molluscs and other benthic organisms. Coastal wetlands also contribute to ecological and hydrological integrity by moderating the erosive power of storms, and by absorbing and retaining nutrients, heavy metals and other contaminants.

The Nature Conservancy of Canada (NCC) has acquired 5100 acres of land in the southwestern part of Norfolk County. The project area is called Norfolk Forests and Long Point Wetlands (NFLPW) and is located roughly 10 kilometres northwest of the Big Creek and Long Point National Wildlife Areas. This part of Norfolk County has long been a hotspot for conservation initiatives. It is home to more than 45 provincially, nationally, or globally rare plants and animals – one of the highest densities of rare and endangered wildlife in Canada – and provides critical staging habitat for migratory birds. NCC's goal in Norfolk County is to ensure the long-term protection and natural



Figure 1. DeMaere 2 Property – November 8 2010. First push with a D6 LPG hightrack bulldozer (photo credit: NCC).



Figure 2. Rendulich Property – August 23 2011 – Excavating an oxbow scar in the Big Creek floodplain (photo credit: NCC).



Figure 3. Demaiter Property – June 4 2013  
– Removing tile drains (photo credit: NCC).



Figure 4. Soenen 2 Property created  
wetland – May 2010, one week after  
bulldozer was moved offsite (photo credit:  
NCC).



Figure 5. Soenen 2 Property created  
wetland – July 2011 (photo credit: NCC).

legacy of some of southwestern Ontario's best remaining natural areas.

### **Methods**

Many of the land parcels secured in the NFLPW project area have large tracts of mature Carolinian forest as well as agricultural land. A reality of securing conservation lands in southern Ontario is that properties often have some agricultural areas. One of the long-term goals of the NFLPW project is to restore the agricultural land by planting a diverse mix of native tree, shrub, wildflower, fern, and graminoid species to bulk up and connect existing natural areas, specifically Backus Woods, the South Walsingham Forest Complex, the St. William's Conservation Reserve, and Long Point.

Techniques such as direct seeding, planting of nursery stock, and earthmoving to enhance topographical features are all used as methods to help recreate the features that would have been found prior to settlement and contribute to the improvement of water quality in Long Point Bay. Strategies used to recreate perched wetland habitat include using bulldozers and long-reach excavators to exaggerate existing low-lying or wet areas on agricultural fields and removing, blocking or altering tile drains to retain moisture on the surface.

Potential wetland areas for each property were determined from air photo interpretation and site visits. In areas with hydric soils or with seasonal flooding were identified in the field. For most projects a bulldozer was used to accentuate depressions (Fig. 1). On the Rendulich Property, an oxbow scar was identified in an agricultural field and this feature was excavated (Fig. 2).

One of the challenges for wetland restoration in agricultural landscapes is identifying and managing drains. This also provides an opportunity for restored wetland to compliment local drainage systems. In areas where tile drains were identified, NCC worked with the local drainage superintendent to ensure neighbouring

properties would not be impacted when tile drains were removed (Fig. 3).

### **Results**

Earthmoving to create wetland and dry sand dune habitat has been completed on 14 properties in the NFLPW project area. About 110 acres have been restored to open water and seasonal wetlands since 2009. Most of the created wetlands are perched and are therefore ideal for amphibian and reptile species, many of which are federally and provincially listed as Special Concern, Threatened, or Endangered.

### **Discussion**

The logistics of these earthmoving projects can be challenging. Designing the work plan, contractor selection, approvals, funding conditions, ensuring regulatory due diligence is complete, overseeing the work, and dealing with unforeseen challenges are all part of the process.

Overall, the restoration results are very positive. In addition to the immediate benefits of retaining water on the landscape (Fig. 4), the restored wetland provide habitat for a variety of species. NCC has implemented a program to monitor the succession of wetland vegetation and changes in wildlife use. Even after only one year following restoration, the cover and diversity of wetland-dependent plants is very high (Fig. 5). NCC will be continuing to monitor and report on the results of wetland restoration on these properties.

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## RESTORATION

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*Huber Wetland in Oxford County  
Photo Credit: Ducks Unlimited Canada*

# Wetland Restoration in Lake Ontario: A Case Study of the Rehabilitation of Corner Marsh using Adaptive Management Ontario

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## Introduction

Prior to human settlement, Lake Ontario supported extensive coastal wetlands that were associated with the outlets of the many rivers mouths, as well as the complex shoreline conditions. These wetlands represent “Biological Centers of Organization” that drive the nearshore fish and wildlife communities as well as contributing significantly to the overall health of Lake Ontario. As a result of shoreline and watershed development, lake filling, stone hooking, and water level control, we have lost most of these original wetlands and most others are in declining health. Wetland restoration is therefore critically important and needed to improve the overall health of the Lake Ontario watershed.

Wetlands have been a large focus of the Toronto and Region Conservation Authority’s (TRCA) restoration programs since the early 1990s. There have been many successes and failures; however the use of adaptive management has emerged as the single most important approach to the science of wetland restoration. Wetland restoration in the coastal Toronto Region is driven by a complex mix of factors that are primarily attributed to: water levels, water quality, water temperature, and European Carp populations. These factors are the most significant determinants to the condition of the submergent and emergent vegetation communities, which are the drivers of wetland health.

Corner Marsh is an 18 ha lagoon within the Duffin’s Creek Coastal Marsh Complex located in the Town of Ajax. TRCA has documented the degradation of this complex since the mid 1970’s, and began restoration planning late 1990’s. In 2005, wetland management efforts included the construction of a levy which would facilitate water level manipulation and carp exclusion. The project

has been successful in restoring: significant emergent vegetation communities, improving water clarity, and increased wildlife utilization. This paper outlines the success of this wetland restoration project, and represents an ideal case study to document how success is attributed the adaptive management of the driving factors.

## Water Levels and Water Level Control

The key to the success of coastal wetland restoration is the establishment of healthy robust emergent and submergent vegetation communities. These typically require clear water that is less than 1.5 m deep, which promotes the penetration of sunlight to the lake bottom. The establishment of emergent vegetation increases nutrient uptake, creates habitat structure, improves soil and sediment stability, decreases turbidity, and increases water quality.

Coastal marsh water levels are primarily driven by lake levels; however terrestrial inflow and their degree of isolation also play a critical role. Historically, water levels in Lake Ontario were highly variable with exceptionally high and low water levels (Fig. 1). This variability, coupled with changes in annual precipitation, created significant water level fluctuation and resulted in a dynamic expansion and contraction of aquatic vegetation. This variability is a fundamental requirement of healthy, diverse emergent and submergent communities.

Since human control of water levels began in the 1960s, year-to-year water levels have become more stable (Fig. 1). The variability range has been dramatically reduced, and the extreme lows have been essentially eliminated. It is typically these lows that result in expansion and establishment of emergent aquatic vegetation. High water levels could also promote expansion; however, many of the coastal wetlands within the Toronto Region

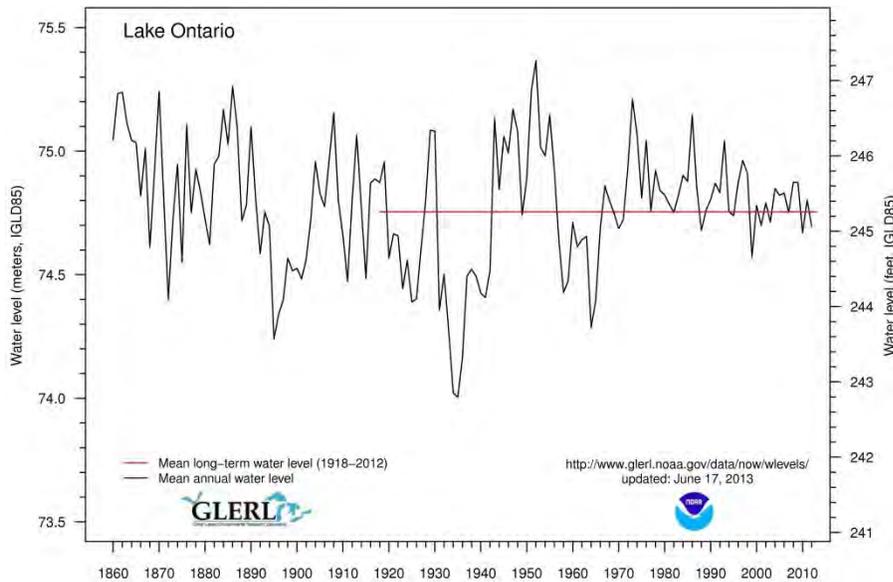


Figure 1. Historic water levels in Lake Ontario. Note the decreased overall variation since water level control began in the 1960s.

hydroperiod which is not directly dependent on seasonal precipitation. Lake Ontario Water Levels are now managed for summer shipping conditions, and are typically highest in mid-summer instead of spring (Fig. 2). Late spring and summer are the best for vegetation growth, as the photoperiod and temperature are optimal. However under lake wide water control, water

levels rise in spring to summer. This results in emergent and submergent

have developed perimeters, thus preventing expansion.

A second aspect of water level control is its influence on hydroperiod or water level seasonality. Under a natural regime, in-year water levels would correlate with the seasons. As spring arrived, wet conditions and melting snow would cause water levels to rise. The water levels would then gradually drop as spring changed to summer, warming the water and creating ideal growing conditions for emergent vegetation in the near shore environment. Water levels would continue their gradual drop into late summer and autumn, maintaining warmer temperatures and promoting vegetation growth and spatial expansion (Fig. 2). Water level control now exhibits a very different

conditions that are colder and deeper during this optimal period which inhibits the establishment and expansion of aquatic vegetation.

Large scale coastal wetland restoration, therefore, requires some ability to control or manipulate water levels as the natural lake wide regime

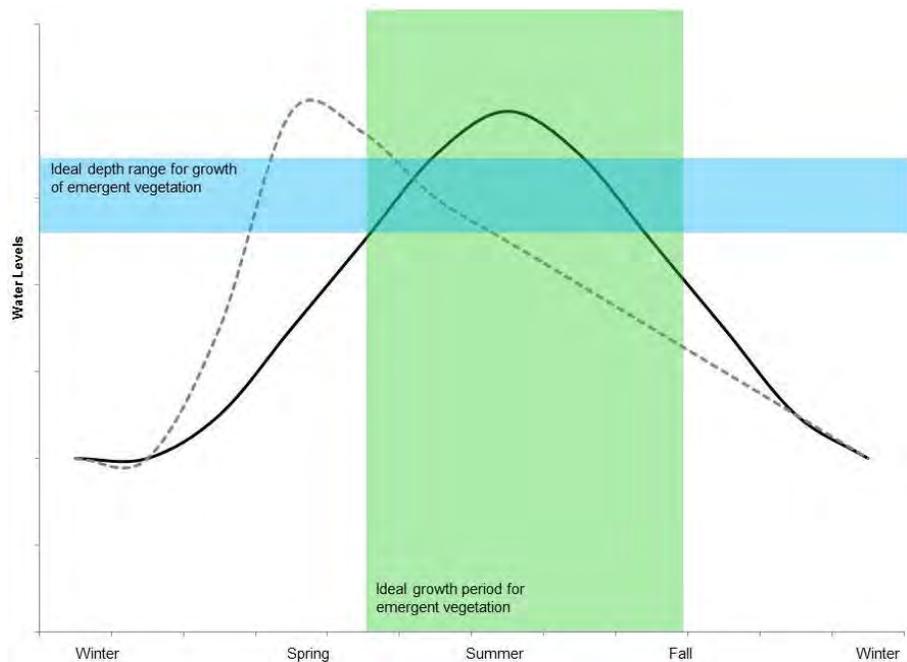


Figure 2. Comparison of typical in-year water levels before (dashed line) and since (solid line) control of water levels. Note seasonal changes associated with snow melt and dry seasons prior to human control and the later peak in water levels since human control.

## Restoration

promotes stagnation and regression. Installation of water control structures allows TRCA to maintain ideal growing conditions inside the wetlands for key periods including; establishment, and during times of wetland renewal. The goal is to adaptively manage levels in wetlands to promote vegetation expansion, however the ultimate goal is to have direct hydraulic and aquatic connectivity for the majority of the year or in most years depending on the project.

**Corner Marsh Case Study** – In 2005, a water control structure was installed into a constructed levy of a northwest lagoon of Duffin’s Creek Marsh known as Corner Marsh. The water control structure and pumping system provide the opportunity to control water levels within the wetland independently of Lake Ontario. The wetland was effectively isolated in 2005 however complete water level control was not achieved until the end of 2006. Starting in March of 2007 the wetland was maintained in draw down condition for the entire growing season. The aquatic vegetation communities reestablished quickly (Fig. 3 and Fig. 4). Vegetation expanded from less than 10% coverage prior to water level control to just over 50% coverage after one growing season. The three most dominant species which established during the year one included cattails (*Typha* spp.), swamp smartweed (*Polygonum hydropiperoides*), and eastern cottonwood (*Populus deltoides*). Significant proportions of willow (*Salix* spp.) were also found, as well as non-native, purple loosestrife (*Lythrum salicaria*).



Figure 3. Fall 2007 aerial photo of Corner Marsh showing aquatic vegetation expansion and establishment after one season of draw down. The newly established green vegetation is clearly visible.

Vegetation expansion exceeded expectations, however the presents of non-native loosestrife and terrestrial eastern cottonwood was not anticipated. In response to these undesirable species, water was pumped back into the wetland in the fall of 2007 to promote the further establishment of the emergent communities. Water levels were manipulated during the next two growing seasons to foster native emergent and submergent communities which by 2009 were dominated by *Typha* spp., *Salix* spp., and *Scirpus* spp. In 2009 non-native *Phragmites* was observed and remains a concern for management.

### Water Quality and Turbidity

Water quality is a crucial element contributing to the degradation of wetland habitat in the Lake Ontario watershed. It is also one of the critical factors that must be considered in the planning for restoration of coastal wetlands. Turbidity is the dominant water quality component that must be addressed to achieve success in coastal wetland restoration. Healthy functioning coastal wetlands typically exhibit clear water conditions and support a diverse aquatic vegetation community. Instead, we typically see low species richness and high turbidity within the coastal



Figure 4. Photos of Corner Marsh showing high turbidity before (on left) and low turbidity after (on right) carp exclusion and water level control.

wetlands of the Toronto Region. Turbidity in coastal wetlands is a function of many factors. Directly factors include; the turbidity of incoming waters, and substrate characteristics. Indirectly, turbidity is a function of emergent and submergent vegetation coverage, common carp abundance, lake seiche influence, wind fetch, and resuspension.

A healthy community of emergent vegetation provides stability of the sediment bed and filtration of the water column, preventing suspension of particles and increasing water quality. It also provides a physical barrier to wind and seiche driven currents that can suspend fine particles. Insufficient emergent and submergent vegetation creates conditions that act synergistically with lake currents, turbidity, poor water quality, and presence of carp in a positive feedback loop that suppresses the re-establishment of a functional coastal wetland system and leads to continuous degradation.

*Corner Marsh Case Study* – Dramatic reductions in turbidity were observed in Corner Marsh following the isolation of the marsh and the reestablishment of the emergent and submergent vegetation communities (Fig. 4). Although the Duffin’s Creek is the Toronto Region’s least-degraded watershed, the main channel is a constant source of turbidity. Figure 5 clearly shows the high turbidity in the un-restored cells. These other cells show little or no significant vegetation growth and expansion due to limited light penetration in these turbid conditions. These conditions cause a positive feedback loop in which the lack of vegetation creates the ideal conditions for sediment resuspension of these unstabilized sediments from seiche influence, wind fetch, carp activity, and lack of filtering ability.

### European Carp Exclusion

Invasive common carp of the Cyprinidae family negatively impacts coastal wetlands in several ways. This large-bodied species typically dominates the fish biomass of coastal wetlands and embayments. They cause significant damage to submergent and emergent plants by grazing and feeding directly on the vegetation, as well as



Figure 5. A 2009 aerial Photo of Corner Marsh showing significant water clarity and reduced turbidity after restoration in comparison to the three other Duffin’s marsh cells.

indirect damage to vegetation though the act of spawning and feeding. Secondly the resulting disturbance and increased turbidity from their feeding and spawning activities hinders growth of vegetation.

The impacts of common carp, like turbidity, act to synergistically limit aquatic vegetation further enhancing the positive feedback loop. To exclude carp from restored wetland areas, TRCA has utilized removable metal gates. The spacing on the bars in the gates prevents passage of large-bodied mature carp while allowing free passage of most native species. TRCA has seen considerable success using these gates to exclude carp from restored coastal wetlands

*Corner Marsh Case Study* – Excluding carp from Corner Marsh was a key contributor to the increase in water clarity and ultimate increase in aquatic vegetation. The installed fish gates excluded carp larger than 34 cm from entering the marsh. The gates were functional in 2005. Significant water clarity improvements were observed in Corner Marsh in 2005 and 2006 when the wetland was isolated and carp excluded, but the water levels were not yet manipulated. While turbidity was dramatically reduced, significant

## *Restoration*

vegetation establishment and expansion was not realized until 2007 when the marsh was drawn down. This suggests that carp alone are not the only factor impacting Corner Marsh, but the interaction with water levels and turbidity creates a complex of factors.

A key goal of the TRCA's wetland restoration strategies is to restore all ecological functions to marshes. A large component of this is to provide fish habitat and connectivity to the Lake. While the gates are designed to target large-bodied carp, and should not restrict other native species, some large mature native species may also be restricted. Therefore it is desirable to remove the fish gates for portions of the year or in selected years to allow unrestricted access for all species. The gates can be adaptively managed in response to the condition of the wetland environment.

### **Essential Habitat Structures**

When restoring coastal wetland habitats, TRCA installs essential habitat features to help re-establish native species and proper function. The primary habitat feature TRCA installs in coastal wetland restoration projects is emergent vegetation. A variety of species are planted by hand or seeded. Once established, this vegetation serves as direct habitat for a wide variety of aquatic species, birds, amphibians, and reptiles. This vegetation is planted in areas that are lacking in significant natural regeneration or are dominated by undesirable species. Planting is also very important in places where water level control or turbidity cannot be managed.

General habitat structures such as log tangles, stone piles, snags, or cribs, varied substrates, and general varied topography are also installed or created in wetlands. This creates heterogeneity and structural diversity. It often provides missing structural habitats needed to complete lifecycle processes, or aids in colonization and range expansion. Other essential habitat features are installed to target specific species. Examples include wood duck boxes, turtle nesting areas, basking logs, tern nesting rafts and mounds.

*Corner Marsh Case Study* – The increase of emergent aquatic vegetation seen in Corner Marsh will: provide important cover for all fish species, including young of the year, forage, top predator, and post-spawn fish; improve species richness; and provide structure to ultimately improve the fish community.

## Application of Field Experimentation and Monitoring in the Restoration of Wainfleet Bog, a Mined Carolinian Peatland

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### Introduction

Wainfleet Bog (1460ha), located on the Haldimand Clay Plain at the eastern end of Lake Erie, is the largest remaining peatland feature in the Carolinian life zone of Ontario (Frohlich 1997). Much of this bog/swamp complex has been severely disturbed by over 80 years of peat extraction which created a patchwork of harvested fields bordered by drainage ditches. Areas of exposed catotelmic peat were subject to extensive frost heaving, summer droughts, frequent fires and supported only three main plant species, dominated by the non-native European birch *Betula pendula* (Fig. 1).

Much of the mined portion was purchased in 1997 by the Nature Conservancy of Canada and subsequently transferred to the Niagara Peninsula

Conservation Authority. A restoration plan was developed that same year and its implementation begun in 1998. A key goal of this was the restoration of saturated surface conditions for the re-establishment of *Sphagnum* and peat accumulation processes (Frohlich 1997). An adaptive management strategy was followed that included an initial three year period of baseline studies, experimental manipulations of abiotic, biotic and dispersal filters to examine the impact of different restoration management options, and long term monitoring of these field trials. The eastern portion of the bog was left unaltered to provide a control area (Browning et al. 2006). A 230 ha dome of peat in the northeast corner of the feature has never been mined and this designated Area of Natural and Scientific Interest (ANSI) also provided a reference area.



Figure 1. Summer 2004 flooding at Wainfleet Bog. Water from a dammed drainage ditch is spreading across a vacuum-mined peat field. The three primary plant colonizers, dense cotton-grass, hair cap moss and European weeping birch can be seen in this photo. The secondary successional plant community has not yet become established.

### Methods

Interactions between the three primary colonizers of the vacuum-mined peat fields were examined for all species pair combinations. Young plants of tussock cotton-grass (*Eriophorum vaginatum*), bog haircap moss (*Polytrichum strictum*) and European birch were transplanted into well-established communities of the other two species that had been thinned to different densities. Growth and survival of transplants were measured after 25 months. Experimentally created gradients of peat volumetric water content (VWC) and nutrient levels (N, P, K, Ca)

were combined to allow a comparison of the impact of each of these on the developing plant community (both sown fragments of the ribbed bog moss, *Aulacomnium palustre*, and naturally seeded colonizers). Vegetation establishment in these plots was measured after 3 years. Fourteen peat dams were constructed to block internal drains. A series of wells and staff gauges were built to follow changes in the peatland hydrology created by the dams. Five years after peat dam construction Beaver recolonized the bog and built 3 main dams on the drainage network. A Before-After/Control-Impact Paired Series design (Stewart-Oaten et al. 1986, Osenberg et al. 2006) was used to assess the impact of both peat dams and beaver dams on water table position. Portions of nine peat fields within the area of influence of the peat dams were randomly selected for clear cutting of European birch. Birch regeneration was cut again after four years. Transects running perpendicular to the blocked drains were used to assess the impact of drain blocking and birch clearing on vegetation establishment after seven years. Finally, young plants of five native bog species, common Labrador tea (*Ledum groenlandicum*), sheep-laurel (*Kalmia angustifolia*), large cranberry (*Vaccinium macrocarpon*), few-seeded sedge (*Carex oligosperma*) and papillose peat moss (*Sphagnum papillosum*), all present in the regional species pool but missing from the developing secondary successional community, were transplanted into cleared and intact plots to assess the relative importance of biotic, abiotic and dispersal filters in explaining their absence.

### Results

Almost all of the biotic interactions between the three primary plant colonizers were facilitative. This was the case for both growth and survival. The strongest pairing involved the mutual facilitation of growth between the two natives: hair cap moss and dense cotton-grass. Both of these species also survived and grew better under a canopy of European birch. Birch seedlings also did better when grown next to cotton-grass tussocks (Fig. 2). However, the growth of birch seedlings planted into mature hair cap moss

carpets was reduced by 30 – 40%, the only instance of competition between the primary colonizers. Environmental measurements taken over the course of this experiment indicated that the advantage of a mature cover to transplants was less frost heaving, higher peat levels of P and K, and an altered microclimate (higher relative humidity, less variable air temperatures near the peat surface).

Phosphorus was found to be the primary limiting nutrient in the mined peat fields. This was true for European birch and the ribbed bog moss although the optimum level of P varied substantially between these two species. However, where both hydrology and nutrient treatments were used in combination, the hydrology gradient had a much greater effect on plant establishment than any of the nutrient treatments. For example, on hummocks at the dry end of the moisture gradient created by the digging of microtopography sequences, there was no significant effect of P on establishment of the ribbed bog moss in contrast to significant effects in flat and hollow plots. The moisture gradient had a significant effect on the total number of naturally colonizing species (highest in hollows and lowest on hummocks) while the nutrient gradients had no effect.

Long term trends in the hydrological response to ditch blocking included substantial increases in water table position (+25-50 cm), surface water elevation in internal drains (+50-70 cm) and surface peat VWC (+13-18%). The impact of beaver dams was much greater than peat dams both in terms of effect size and aerial extent. The relative importance of beaver dams was also greatest during periods of drought in the bog in contrast to peat dams (Fig. 3). Reasons for these differences appear to be due to both dam design and chosen location.

These hydrological changes have resulted in elongate zones of a secondary successional plant community developing parallel to blocked drains (Fig.4). There has been an increase in the number and cover of primarily wetland generalists and peatland specialists, particularly within 5 m of



Figure 2. A dense cotton-grass plot thinned to one tussock. Seedlings of European birch have been planted directly under the overhanging outer leaves of the tussock, at 35 cm away and at 70 cm away. (Photo taken in September 2006 after one growing season).

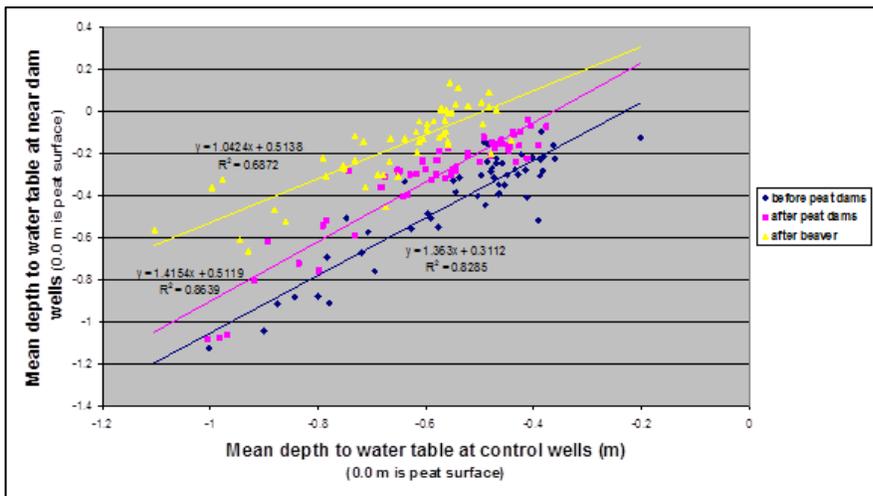


Figure 3. Impact of peat dams and beaver on water table position at wells within 150 m (upstream) of a peat dam.



Figure 4. The secondary successional plant community developing parallel to a blocked drainage ditch (September 2006). Notable species include leatherleaf, Canada rush, silvery sedge, tawny cotton-grass and southern tickseed.

## Restoration

drain margins, including Canada rush (*Juncus canadensis*), leatherleaf (*Chamaedaphne calyculata*), marsh St. John's-wort (*Triadenum fraseri*), tawny cotton-grass (*Eriophorum virginicum*), silvery sedge (*Carex canescens*) and roundleaf sundew (*Drosera rotundifolia*). These vegetation changes lagged several years behind the initial increases in surface peat VWC and standing water which in turn lagged approximately 1.5 years behind initial increases in water table position produced by peat dams. Birch cutting had little effect on this developing secondary community.

Growth of the five missing bog species transplanted into intact and cleared plots of this secondary successional community was reduced by the presence of plant neighbours, especially for cranberry and few-seeded sedge, the two species with strong horizontal growth patterns. *Sphagnum papillosum* was the only species whose growth was not affected by the surrounding plant community. However, there was no impact of neighbours on the survival of any of the transplanted species and at least some individuals of each species (except *Sphagnum*) flowered in uncleared plots.

### Discussion

The three primary colonizers of the mined peat fields formed a highly stable, novel plant community (*sensu* Hobbs et al. 2009). Stability was due to direct and indirect facilitative interactions found between European birch, dense cotton-grass and hair cap moss which produced a network of positive feedback loops based on both survival and growth. This primary community was likely in a stasis phase of restoration (Halle 2007) where the system could not cross a threshold without significant active management for restoration.

Results from the fertilizer addition experiment indicated that P was the main limiting nutrient in the mined peat fields. However, increases in peat VWC were much more important in driving plant succession than changing nutrient levels. Blockage of drainage ditches produced significant increases in peat VWC with beaver dams being more

effective than artificial peat dams. Because beaver have now cut through many of the original peat dams upstream from their own dams, these beaver dams should be maintained if the animals move on to new locations. New peat dams now need to be constructed in the southern and eastern portions of the bog, unaffected by previous drain blockings, to speed the establishment of a secondary successional community there. Dams should be designed with smaller "wing dams" or bunds extending outward from the main structure and should be located at "T" intersections to mimic beaver dams.

Restricted dispersal, rather than competition or other abiotic factors, appears to be the main factor limiting further colonization of the secondary successional community by new bog species. Sowings, plantings or spreading of stem fragments (in the case of *Sphagnum* species) will likely be necessary, possibly combined with some vegetation clearing, to enhance community assembly. The presence of more standing surface water should also help the spread of species relying on hydrochorous dispersal (water transport).

The initial process of peat mining, combined with the much later restoration management actions and the arrival of beaver has moved portions of the bog back to an earlier successional stage. The peat surface is now very much under the influence of the local water table and dominated by *Cyperaceae* (*Carex*, *Eriophorum*, *Scirpus*) and *Juncaceae* (*Juncus*) as the secondary plant successional community becomes established. Moss carpets of species including hair cap moss, ribbed bog moss and *Sphagnum papillosum* arising from sowings now cover a much greater area than do bryophytes in the unmined ANSI. Conditions are more like those 350+ years BP as inferred from stratigraphy, pollen analysis and radiocarbon dating of Wainfleet ANSI peat cores (Nagy 1993).

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## Wetland Restoration in Oxford County – Stewardship Oxford Partnerships

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### Introduction

Stewardship Oxford (SOX) is a group of 15 conservation-minded volunteers from different walks of life who come together to develop and deliver conservation projects that provide ecologic benefits in Oxford County. As community leaders, private landowners, resource agency staff and concerned citizens, SOX engages all community sectors and networks to influence and deliver land stewardship activities. These activities are aimed at retaining, restoring and enhancing local natural heritage, and improving human health in Oxford County. The program is aimed at influencing land management decisions, rather than controlling them. Through active partnerships with social service providers, schools, private landowners and resource agencies, SOX delivers a message of sustainable ecosystem management. SOX respects and appreciates private land owners and their right to make decisions on managing their land, but tries to educate and assist people in making ecologically sustainable land management decisions. Reforestation, road side tree planting and native prairie restoration are projects of interest but wetland restoration is a major focus for SOX. The group collaborates with conservation partners to provide technical and financial assistance to private landowners and municipalities with respect to implementing wetland conservation projects on their property. SOX is a private, incorporated nonprofit organization.

Ducks Unlimited Canada (DUC) conserves, restores, and manages wetlands and associated habitats for North America's waterfowl. These habitats also benefit other wildlife and

people. A private, registered charitable organization, DUC partners with government, industry, other non-profit organizations, and private and public landowners to conserve wetlands. Using sound science, DUC delivers on-the-ground habitat projects, land stewardship, research, education and policy programs and initiatives to conserve, restore and manage wetlands across Canada. DUC has been active since 1938 and began direct wetland conservation activities in Ontario in the mid-1970s. Today DUC delivers wetland conservation in all areas of the province. Protection of Ontario's existing wetlands and the restoration of lost and degraded wetlands are critically important to a healthy, productive landscape and provides substantial benefits to all Ontarians. In addition to other conservation efforts, DUC provides technical and financial assistance to landowners who are interested in wetland conservation activities on their property. DUC in Ontario includes a strong, grassroots volunteer conservation effort with



Figure 1. Mr. Phil Holst, the principle volunteer for wetland projects with Stewardship Oxford.



Figure 2. Huber wetland project west of New Dundee, Ontario in Oxford County.



Figure 3. Group photo of project partners on tour in summer 2011.



Figure 4. Willits Wetland Restoration project, Woodstock, Ontario at highway 401.

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biological, engineering and support staff required to implement a sustained and efficient wetland conservation program across the province. Ducks Unlimited Canada believes that partnerships in conservation are critical to leveraging the necessary resources and capacity to deliver wetland restoration program success.

### Stewardship Oxford/Ducks Unlimited Partnerships

*“Habitat for Healthy Waters” Program* – For many years, SOX and DUC worked independently to implement stewardship and wetland projects across Oxford County. In 2005, stewardship councils in Oxford, Middlesex and Elgin collaborated with DUC to deliver the “Habitat for Healthy Waters” (HHW) program.

A multi-year collaborative program, HHW provided DUC mentoring to council volunteers, in-kind technical support and partial funding for wetland restoration and enhancement projects. In Oxford County, SOX provided in-kind volunteer support in identifying potential project sites, applied for and secured applicable regulatory approvals and worked with the landowners to help deliver the projects. The program was a complete success. SOX volunteers gained expertise in wetland restoration and enhancement techniques, biological design, regulatory processes and contractor supervision. A total of nine projects were completed in Oxford, and many more in Elgin and Middlesex. Direct



Figure 5. Post-construction photo in fall 2013 of the Thames River Wetlands (Oxbow) project at Beachville, Ontario.

funding for the program was provided by the partners: Ontario Stewardship, DUC and the Ontario Trillium Foundation (Figs. 1 and 2).

*“Ontario Wetland Care” Program* – In 2009, SOX and DUC collaborated to begin implementing a new partnership in wetland restoration. The “Ontario Wetland Care” program is set up to share resources and funding to deliver a full service wetland stewardship program to cooperating landowners. DUC and SOX provide technical assistance (staff and volunteers) and the two organizations share in the direct cost of implementing the projects. Cooperating landowners are obliged to contribute a small amount of cash; approximately 10% of the project budget to a maximum of \$1,000. The range of project elements includes priorities for both organizations involved and include: wetland restoration, enhancement and creation; permanent wetland buffers; cattle exclusion fencing; native grass restoration; turtle nesting sites; snake hibernacula and waterfowl nesting boxes. Occasionally, landowners are interested in other stewardship activities such as tree planting and this is usually accommodated by SOX through other partnerships and funding sources. An example would be funding provided by the Trees Ontario 50,000,000 trees program. Project design, budgets, regulatory permits and invoicing is a shared responsibility but implementation is now completed by SOX volunteers with moderate DUC staff oversight and input.

SOX and DUC have completed 14 “Ontario Wetland Care” projects with some locations having multiple wetland segments. The total direct cost of implementing these projects now exceeds \$200,000 with in-kind staff and volunteer support and landowner cash adding value to the projects.

The ultimate goal of the partnership is to restore, enhance and create waterfowl habitat, realize improved water quality and quantity benefits on the landscape and increase local wildlife habitat and species diversity. This includes species at risk (Fig. 3-5).

### Partnership Benefits Realized

- Leveraging of resources not available or lacking when working independently.
- Mentoring, sharing of expertise (technical or other).
- Leveraged funding, cost sharing in delivery, collaboration can improve funding application success.
- Local partner can be a recognizable local champion and can bring increased credibility because they are volunteers working in their own communities.
- Improved cooperation when working with outside agencies and regulatory.
- National partner brings brand recognition and expertise to the community/project.
- Leveraged goodwill, landowners involved often influence neighbours, increased awareness and program uptake.
- Coordination of activities and program delivery, simplified process for landowner participants.
- Reduction in construction costs realized when working with known local contractors.
- Project monitoring by local volunteers, maintaining connection with landowners.
- Increased access to media, communications, profiling of program and successes.

### The Big Picture

Partnerships must ultimately be equitable and work for each partner involved. Effective long term partnerships are built on mutual trust and a respectful relationship. SOX and DUC have benefitted greatly from taking this approach and have been working collaboratively for almost 9 years now. Retaining people long term (staff and volunteers) is critical to the success of our shared program. This approach provides continuity of program and the opportunity to develop and retain expertise which ultimately improves customer service, uptake and success of the program on the landscape. Another important consideration for the partnership is to have an awareness of how the program and work

completed fits into higher level priorities. This includes high level partner objectives but also includes the objectives of outside agencies whether they are local, provincial or federal. Knowing the higher level objectives is important when it comes to accounting for the work completed, communicating the benefits of the program to others, engaging new partners, completing funding requests and engaging decision makers (Appendix, Table 1).

The SOX and DUC partnership contributes to the following priorities:

- Meets SOX objective of providing meaningful volunteer opportunities for local people interested in stewardship and the environment.
- Meets SOX objectives to educate local people, improve the local environment, assist property owners in improving their properties to benefit wildlife, increase habitat and species diversity, and provide for improved water quality and quantity on the landscape.
- Meets DUC objectives to engage local partners to address habitat impairment; retain, restore, enhance, and create wetland habitat to benefit waterfowl populations. These actions also benefit other wildlife and people.
- Meets DUC objectives to realize increased capacity to have a bigger impact on the landscape.
- Fits with identified local priorities of the *Oxford Natural Heritage Study and Implementation Recommendations*. This includes education, protection, restoration, and enhancement of habitats.
- Fits with provincial protection, retention, and improvement of habitat for species at risk.
- Fits with provincial objectives identified in the *Ontario Biodiversity Strategy* by engaging people and providing habitats that reduce threats to biodiversity and increase ecosystem resilience.

## *Restoration*

- Fits with federal priorities in the *Ontario Great Lakes Strategy* by maintaining and increasing the ecological value and functions of wetlands.
- Conservation of wetlands addresses issues identified in the bi-national *Great Lakes Water Quality Agreement*: reduction of nutrient inflow to the great lakes, reduction of wetland habitat loss as a contributing factor in water quality in the Great Lakes, the protection of ground water quality, and mitigation of climate change.

## Appendix

Table 1. A sampling of recent wetland restoration initiatives across Ontario. One theme that is occurring is that flat areas within valley lands along creeks are being restored to have wetland pools that retain water. This is greatly needed for wildlife and for Great Lakes water quality. Another developing restoration theme is to work more collaboratively with Drainage Engineers to design wetlands as a part of municipal drains. Last year's partners and several others continue to advance some quality wetland restoration opportunities for 2014

Group	Contact	No. of Projects	Wetland Size (acres)	Years of Collaboration	Challenges in 2013	Benefits
Rural Lambton Stewardship Network	519-809-5767	6	10	2004-Present		2 creek valley projects
Elgin Stewardship Council	519-631-4491	2	4.1	2006-Present		2 creek valley projects
Middlesex Stewardship Council	519-245-3701 ext. 224	3	6.15	2007-Present		Creek valley wetland
Cattish Creek Conservation Authority	519-773-9037	3	11	2006 & 2010-Present		Creek valley wetland
Lower Thames Valley Conservation Authority	519-354-7310 ext. 230	5	91	2012-Present		2 creek valley projects
Ausable Bayfield Conservation Authority	519-235-2610	1	2.5	2009-Present		Creek valley wetland
Friends of St. Clair River	519-627-3764	1	1	2010-Present		Coastal wetland
St. Clair Region Conservation Authority	519-245-3701	2	18.75	Long history continues		High profile Community supported project
Lake Erie Unit MNR		1	2.25	Most years since 2008	Staff changes Lack of program continuity for landowners	Creek valley wetland
Lake Erie Unit MNR		1	2.25	Most years since 2008	Staff changes Lack of program continuity for landowners	Creek valley wetland
Private landowners -		4	10.25			Creek valley wetland

Group	Contact	No. of Projects	Wetland Size (acres)	Years of Collaboration	Challenges in 2013	Benefits
Private landowners - South-Western Ontario		4	10.25			Creek valley wetland
Lake Simcoe-Georgian Bay Wetland Collaborative	Mike Williams, m_williams@ducks.ca; Project partners: DUC (lead), Lake Simcoe Region CA, Nottawasaga Valley CA, Severn Sound Environmental Association	42 project sites	7660+ of wetland habitat restored	2001-2004	Engineering costs associated with projects Lack of understanding of Drainage Act Lack of resources (i.e. funding, staff, training...)	Improved water quality Improved water storage (GW recharge and discharge) improved aquatic and terrestrial habitat Improved SAR habitat Improved recreational opportunities
(MNR/Norfolk County/OMAF)	dave.richards@ontario.ca					
Long Point Causeway Initiative (LPWBR, Env. Canada, MNR)	Rick Levek	Installation of aquatic and terrestrial ecopassages under the Long Point Causeway Road		2010-2014	Administrative process for approvals and permits, funding, science	Improved wetland function in the LP Wetland Complex Safer passage with wildlife under the roadway
Long Point Crown Marsh Restoration Project (MNR and LPWA)	Eric Cleland, <a href="mailto:eroc.cleland@ontario.ca">eroc.cleland@ontario.ca</a> ; Lands and Waters Specialist, MNR, (519) 773-4749	7 open water wetland areas	714 restored	2008-2014	SARA Fish Habitat – Lake Chub Sucker Habitat Phragmites infestation	Improved aquatic and terrestrial habitat Improved recreational opportunities

## Wetland Restoration in an Urban(izing) Watershed

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### Introduction

The loss and degradation of wetlands in southern Ontario is well documented, with estimates of about 48% or 13,331 acres/5395 hectares of wetlands lost since 1954 in CVC's jurisdiction alone (Lantz et al. 2010). Historically, wetland restoration has been promoted on the basis of enhancing wildlife habitat or appealing to society's appreciation for nature; however, advancing wetland restoration solely upon its intrinsic values is proving to be insufficient to make significant inroads in mitigating habitat loss and degradation in CVC's jurisdiction.

Limited landowner uptake based on traditional approaches to wetland restoration and conservation is likely due to a variety of factors including but not limited to concerns over actual or perceived legislative implications and lack of understanding about the value of wetlands. The latter has been further demonstrated through multiple surveys and reports undertaken by CVC (Dougan et al. 2009, Lura 2012a, Lura 2012b, Trenholm et al. 2013), with consistently higher interest and knowledge surrounding environmental restoration to benefit future generations, trees and wildlife habitat, and water quality improvements than wetland conservation, restoration, and/or (re)creation. Financial incentives have also been identified as instrumental to advancing restoration goals and objectives, particularly in rural communities (Lura 2012a, Trenholm et al. 2013).

Drawing on studies from Sweden, Taiwan and across the United States, it was consistently demonstrated that wetland restoration is the most cost-effective option for water quality improvements in watercourses (Gren 1995, Teng et al. 2012, Bystrom 2000, Hey et al. 2005, Lentz et al. 2013). Not a single study was found to demonstrate that conventional wastewater

treatment was more cost-effective than wetland restoration for the purposes of improving water quality.

The evidence for the role of wetlands in flood abatement has been less well studied, and it is suggested that focusing on restoration of existing wetlands that are at or near their storage capacity (particularly during spring and fall when this service is in greatest demand) may be less effective in contributing to flood abatement. Alternatively, (re)created wetlands should theoretically offer a larger capacity for abatement since they can be manipulated to store as much water as possible and be placed in more advantageous positions on the landscape (i.e. headwaters).

In examining the 1993 Mississippi River flood damages, Hey and Philippi (1995) estimated that excess discharge (i.e. beyond bankfull) was 40 million acre-feet, and if distributed at a three-foot depth would have covered 13 million acres. Given that 26 million acres of wetland were eliminated in the Mississippi watershed since 1780, the authors concluded that restoring what was lost could have "easily" accommodated the flood volume. Ming et al. (2007) sought to estimate the flood mitigation benefits of wetland soil. First, the authors assessed the capital cost of flood abatement as \$0.08 per m<sup>3</sup> based on investment in reservoir construction. They then calculated the value of wetland flood mitigation as the total capacity of wetland water storage (quantity of water in soils when dry subtracted by quantity of water when fully saturated), yielding a flood mitigation value of \$5,700 per ha per year.

It is proposed that a renewed focus on the role of wetlands and associated restoration in mitigating stormwater quantity and quality and, more specifically, on reducing burdens on receiving infrastructure may hold some promise in

## Restoration

appealing to broader societal values. Not unlike the *Clean Water Act, 2006* and associated Sourcewater Protection Plan, that “*establishes a locally driven, science-based, multi-stakeholder process to protect municipal residential drinking water sources and designated private drinking water sources. This process is meant to promote the shared responsibility of all stakeholders to protect local sources of drinking water from threats to both water quantity and water quality*” (CTC Source Protection Region 2012) and the acknowledged need for associated funding, it is proposed that there are direct parallels in mitigating stormwater effects. In Ontario alone, investments to meet projected water needs have been estimated to exceed \$12.6 billion (CWWA 1997), and if only a fraction of these funds were applied to wetland (re)creation, it is proposed that there might be incremental benefits to stormwater abatement.

### Wetland Restoration Strategy

CVC’s Wetland Restoration Strategy (WRS; Dougan et al. 2009) sets priorities for wetland restoration and rehabilitation, and is used as the basis for guiding the associated wetland restoration program. The WRS identified a total of 3,763 ha potential wetland restoration areas, 788.5 ha of which were ranked as high and medium priorities (Fig. 1):

1. Urban Belt: high priority need for wetland restoration but limited potential outside of floodplain and parts of the shoreline;
2. White Belt: high priority need for wetland restoration and considerable opportunity and tending to correspond to headwater areas immediately upstream of urban areas, thereby increasing the value of their hydrological services.
3. Green Belt: low priority need for wetland restoration services in the short term and priority should be given to mitigating future loss of existing wetlands. High priority areas being around the urbanizing areas in the upper watershed.

The WRS also identifies a need for public education and engagement with specific tactics

including: *improve transparency about issues that wetlands can help address, and raise awareness in downstream communities how upstream wetland restoration and enhancement could benefit them*, both of which are consistent with a need to raise the profile of the role of wetlands in flood abatement and benefits to downstream communities.

For each of the identified ‘belt’ areas, case studies are highlighted that respond to priority tactics identified in the WRS. Discussions are also brought forward about the constraints and opportunities of wetland restoration and (re)creation in urban (urban belt), urbanizing (white belt), and rural (green belt).

### Green Belt

Because the priority for wetland restoration is less in the Green Belt, although restoration projects have been undertaken in this area, the focus of this discussion will be on CVC’s wetland hydrology project and more specifically monitoring at Ken Whillans Conservation Area demonstrating the role of wetlands in flood abatement (i.e. July 8<sup>th</sup> 2013 storm event).

### White Belt

Block 51-1: Part of Mt Pleasant Development: block planning initiative that includes the restoration of a reach of Fletcher’s Creek in Northwest Brampton and proposes a series of wetland restoration and creation initiatives. This initiative responds to the WRS and associated tactics:

- Fletcher’s Creek is an identified high priority in the WRS;
- WRS identified tactics include: *‘select sites that improve N/S corridors and focus species-specific efforts well north of the south edge of their range’*

### Urban Belt

Lakeview Waterfront Connection (LWC): CVC and the Region of Peel, in partnership with TRCA and City of Mississauga, are proposing to create a natural park on the shoreline of Lake Ontario located on the east end of the Mississauga

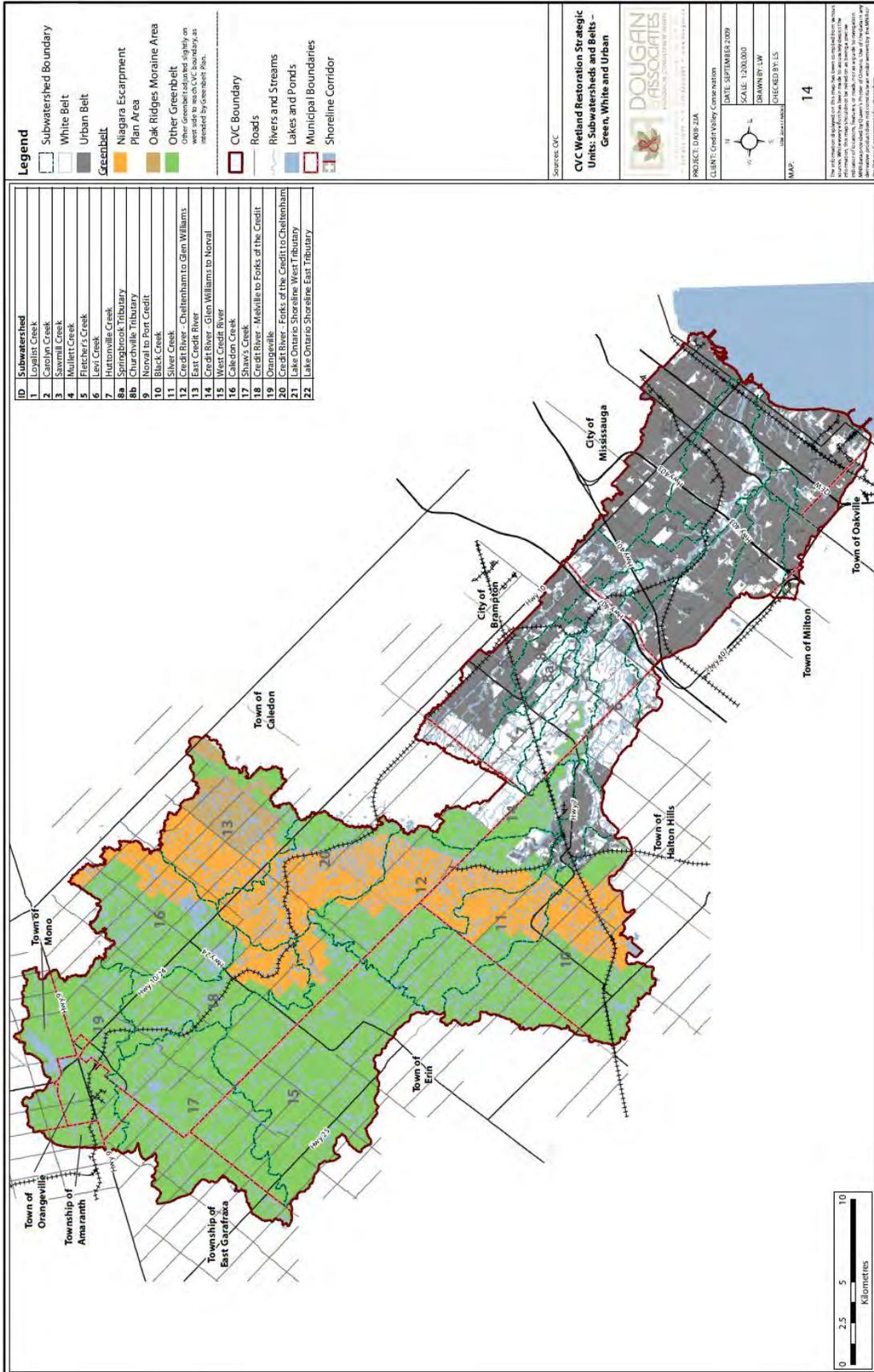


Figure 1. WRS: Green Belt, White Belt, and Urban Belt.



Figure 2. Lakeview Waterfront Connection Preferred Alternative.

shoreline. The LWC project will incorporate between 1.5 to 2M cubic metres of clean fill to establish new beaches, coastal wetlands, streams, meadows and forest habitats along a section of shoreline that is currently highly impaired due to current and historic anthropogenic activities (Fig. 2).

This initiative responds to the WRS and associated tactics:

- Lake Ontario shoreline (East) is an identified high priority in the WRS;
- WRS identified tactics include:
  - *'coordinate with personnel at Lake Ontario Shoreline project'*. The LWC is one of the first and largest habitat (re)creation projects to occur under CVC's Lake Ontario Integrated Shoreline Strategy (LOISS).

### Conclusion

Degradation and loss of wetlands continues to be a major issue throughout CVC's jurisdiction, with

wetland conservation and (re)creation being a very high priority. Challenges related to the conservation, restoration, and (re)creation of wetlands include limitations in opportunities as far as landowner uptake as much as available space. As such, CVC recognizes the need to develop alternative approaches to increase landowner engagement, including facilitating ease of participation in wetland restoration activities through innovative technical and funding mechanisms.

It is also recognized that increased efforts must be made to better understand landowner perceptions and attitudes towards wetland restoration to aid in developing effective messaging that will increase engagement. Focusing on raising both public and agency awareness of both the ecological and hydrological functions of wetlands, and associated economic values of protecting and restoring these features within our watershed for both rural and urban populations shows some promise.

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