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A shoreline divided: Twelve-year water quality and land cover trends in Lake Ontario coastal wetlands

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ABSTRACT

Water quality in Great Lakes coastal wetlands has been studied for decades, but few studies look at water quality changes in multiple sites over many years and relate that to land cover. In this study, water quality at 22 sites in two regions along the north shore of Lake Ontario (Bay of Quinte in the east and Durham Region in the west) was compared over a period of 12 years (2003–2014) and related to land cover data from two time periods (1999–2002 and 2009–2011) at four spatial scales; 500 m, 1000 m, 2000 m wetland buffers, and the quaternary watershed. Water Quality Index (WQI) scores significantly increased over time in both regions, and turbidity and pH both significantly decreased over time in both regions. Land cover data showed regional differences between east and west, with the western sites having higher percentage of urban land at all scales. There were significant relationships between land cover (% Natural and % Urban) and WQI score at several scales, but the relationships were strongest at the watershed scale. We found that sites in the western region showed a greater amount of change in land cover between the two time periods, compared to the eastern sites. The results of this study provide some key insights on the impact of urbanization on Great Lakes coastal wetlands, and on how they can be managed in the future.

Introduction

In the 21st century, the majority of stresses experienced by Laurentian Great Lakes coastal wetlands are anthropogenic. In Canada, the landscape in southern Ontario has changed dramatically over the past quarter millennium, starting in the late 1700s with the arrival of European settlers and the clearing of land for agriculture, followed by the expansion of urban centres as the population increased (Eyles et al., 2013; Whillans, 1982); and, as a result, coastal wetlands and their associated watersheds in the Lake Ontario basin have been affected by a combination of both urban and agricultural stressors (Morrice et al., 2008). The link between wetland water quality and watershed land cover has been well established (Eyles et al., 2003; Morrice et al., 2008), and it has been found that the water in most coastal wetlands is a mixture of watershed (tributary or groundwater) and lake water (Morrice et al., 2011; Trebitz, 2006).

Tributary water quality decreases with increased watershed development. Impacts from agriculture are ubiquitous in the Lake Ontario basin, and manifest as increased levels of nutrients, sediment, and agricultural chemicals in coastal wetlands (Crosbie and Chow-Fraser, 1999; Trebitz et al., 2007). Urbanization is more localized and only affects some watersheds, or parts of watersheds. There are a number of unique impacts of urbanized landscapes on water quality that are associated with a higher proportion of impervious surfaces, such as roads and buildings, which prevent water from infiltrating into the ground and contribute to increased surface runoff. This results in increased nutrients, suspended solids, conductivity, salinity and bacteria in urban runoff (Howell et al., 2012). Storm events in urban areas often result in large volumes of water quickly passing through the watershed, carrying increased amounts of nutrients, sediment, and contaminants (Paul and Meyer, 2001). The relationship between poor water quality in Lake Ontario coastal wetlands and urbanization has been well established and extensively documented in two urban coastal wetlands (Frenchman's Bay and Cootes Paradise) where increased turbidity, conductivity, chloride, total phosphorus, and fecal bacteria were reported (Chow-Fraser, 2006; Eyles et al., 2003; Seilheimer et al., 2007).

From a conservation perspective, it is important to understand the effects of watershed development on wetland water quality because water quality influences flora and fauna community attributes. Lake Ontario coastal wetlands with poor water quality have lower coverage of emergent vegetation (Grabas and Rokitnicki-Wojcik, 2015) and submerged aquatic vegetation (Grabas et al., 2012), which are important components of marsh bird and fish habitat. In addition, coastal wetlands with poor water quality generally have lower fish and vegetation richness and are dominated by fish and aquatic vegetation species that are

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tolerant of poor water quality (Croft and Chow-Fraser, 2007; Seilheimer and Chow-Fraser, 2006). Despite this, urban wetlands still provide valuable habitat, especially in basins where many of the coastal wetlands have already been dredged or filled in (Seilheimer et al., 2007; Stephenson, 1990).

Although the relationship between land cover and wetland water quality has been well established in the Great Lakes, there have been few studies that examine temporal water quality trends in Great Lakes coastal wetlands. This is particularly important in watersheds close to urban centres, which are experiencing rapid urbanization and where agencies are trying to manage and mitigate the negative effects of urbanization on natural systems.

This study was unique in Lake Ontario because it is the first study to use more than a decade of water quality data and associate it to changes in land cover. The primary objective of this study was to investigate how wetland water quality and land cover have changed over a period of 12 years at four landscape scales (500 m, 1000 m, 2000 m wetland buffers, and watershed). As a secondary objective, the hypothesis that changes in land cover are correlated to changes in water quality was tested. Finally, coastal wetland water quality was compared between two regions of the Lake Ontario basin that have different degrees of watershed development, the Bay of Quinte in the east and Durham Region in the west. The results from this work will identify the scale at which land cover influences coastal wetland water quality and provide an indication of the trajectory of wetland condition in Lake Ontario. This information will inform habitat managers as they complete baseline assessments of coastal wetlands and develop and implement watershed management strategies designed to improve wetland conditions.

Methods

Study sites

Water quality data in Lake Ontario coastal wetlands were available for 58 sites for the Ontario, Canada shoreline, but due to sampling infrequency only 22 sites were selected for this study (Fig. 1). The 22 study sites were selected based on their suitability for trend analysis according to criteria laid out by Hirsch et al. (1991). Data were collected as part of a regional water quality monitoring partnership among Environment and Climate Change Canada (ECCC), Quinte Conservation (QC), Ganaraska Region Conservation Authority (GRCA), and Central Lake Ontario Conservation Authority (CLOCA) (Environment Canada and Central Lake Ontario Conservation Authority, 2007; Grabas et al., 2012; Macecek and Grabas, 2011). Study sites represent the following hydrogeomorphic types found along Lake Ontario: protected embayment, open embayment, barrier protected, and drowned river mouth wetlands.

Preliminary analysis of this dataset (not presented here) demonstrated that Lake Ontario sites could be classified into two major groups based on hierarchical clustering analysis of water quality and biotic community attributes: those located on the west (i.e., Durham Region) and those on the east (i.e., Bay of Quinte) of the lake. One factor contributing to this distinction is the higher urban development in the western

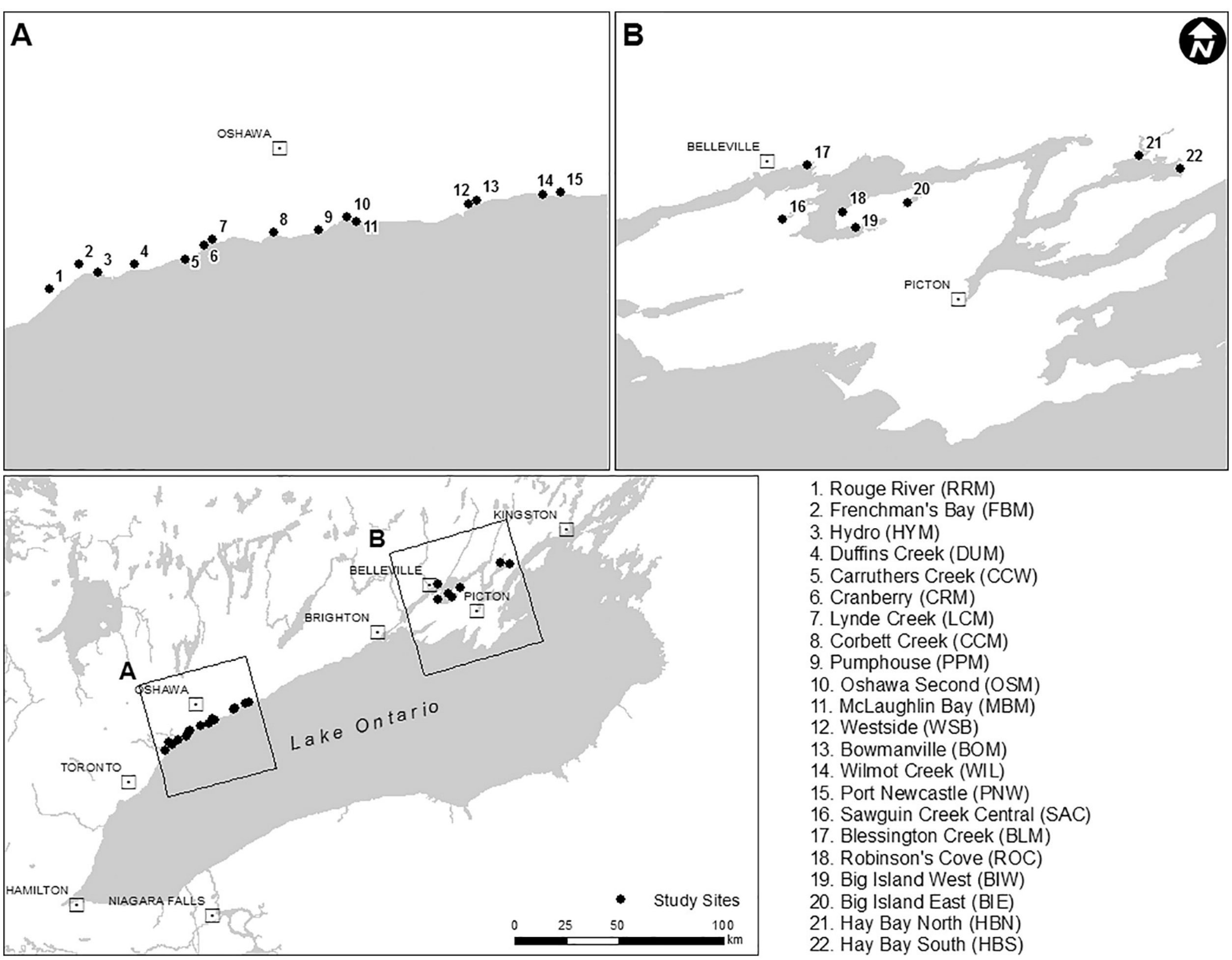

Fig. 1. Location of Lake Ontario coastal wetlands analyzed in this report. Panel A shows a close up of the coastal wetlands located in the Durham region and Panel B shows those located in the Bay of Quinte.

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