

Wetland ecosystem comparison using a suite of plant assessment measures



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ABSTRACT

In light of extensive human impact on wetlands it is necessary that we develop an effective way to monitor the effects of impact in order to prevent further destruction. One method is plant community assessment, specifically Floristic Quality Assessment (FQA), which is common, but can be subjective. In this case study, we implement FQA, as well as specific morphological and chemical assessment measures over a two-year period in order to compare two wetlands in the Lake George watershed in the Adirondack mountains and their response to human impact. While the wetlands studied demonstrated very different water chemistry profiles makeups, FQA did not reveal substantial differences between plant communities. However, more specific analyses of plant morphology and tissue chemistry did reveal significant differences that reflected the level of impact at these two sites. Namely, the simple plant *Lemna minor* had consistently shorter roots and *Nuphar lutea* contained higher amounts of nitrogen in above ground tissues when growing in an anthropogenically impacted wetland. We suggest that FQA and specific plant morphology and tissue chemistry measurements be performed concurrently to provide indication of both long- and short-term effects of human impact in wetland ecosystems.

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1. Introduction

Wetland ecosystems are greatly, and often negatively, affected by human activity despite government protection and conservation efforts (Mitsch and Gosselink, 2000; Kent, 2001). Anthropogenic effects in wetlands can include physical changes such as an accumulation of sediment or alteration of water flow (Freeland and Richardson, 1997; Johnston et al., 2001). They can include biological changes such as a general loss of biodiversity, introduction of invasive species, or shifts in community structure (Helgen and Gernes, 2001; Chipps et al., 2006; Craft et al., 2007). Anthropogenic effects can also be chemical in nature such as the non-point source, or point source introduction of contaminants including excess nutrients, salts, medicinal compounds, and metals (Carpenter et al., 1998; Mitsch and Gosselink, 2000; Tilman and Lehman, 2001). Collectively, these can have a profound impact on the dynamics of a wetland, leading to significant changes in populations of organisms, water quality, and the ecosystem as a whole.

These major changes brought about by humans are of concern because wetlands provide numerous crucial services, including flood control, water filtration, necessary habitat for a wide range of organisms, and even recreation (Mitsch and Gosselink, 2000). However, anthropogenic impact puts all of these services in jeopardy. Additionally, wetlands are often the first habitats to directly receive the barrage of physical, biological, and chemical impact brought on by human activity. This often translates to rapid and irreversible degradation of wetland ecosystems (Holland et al., 1995; Finlayson and Rea, 1999).

With exponential loss of wetlands and their services around the globe, it is imperative that wetlands be consistently monitored in order to assess the level of anthropogenic impact and determine if human practices need to be altered, or if certain effects can be reversed in order to preserve the ecosystem. Many assessment techniques have arisen from this need to monitor wetlands (Adamus and Brandt, 1990; Rader et al., 2001). Some of the most successful assessment methods have utilized wetland plants as the main indicator of anthropogenic influence (Balcombe et al., 2005; Johnston et al., 2008; Johnston and Brown, 2013). Since plants are sessile organisms that cannot uproot in order to move to a more ideal habitat, they must adapt to environmental changes and stressors, or they will not survive (Treshow, 1970). If they cannot adapt to anthropogenic pressures, or if they are intolerant of these

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pressures, specific plant species may disappear from a community. If they readily adapt, they can survive and even dominate an area.

These are the foundational principles of floristic quality assessment (FQA), which is a popular method for determining wetland health, function, and extent of human impact (Andreas and Lichvar, 1995; Lopez and Fennessy, 2002). When utilizing FQA, coefficients of conservatism (COC) are assigned to wetland plants by experienced botanists. COCs range from zero to ten and indicate a plant's level of habitat-type fidelity and ecological tolerance. The subjectivity associated with assignment of COC values has led to skepticism from wetland scientists and managers (Bourdaghs et al., 2006; Johnston et al., 2009). More objective plant assessments can also be utilized for the same purpose, which focus on specific plant physiology and chemistry (Newman et al., 2003; Inglett and Reddy, 2006), although these are not as extensively practiced as traditional FQA and other methods of whole community assessment.

In this study, several plant assessment measures were employed in order to study and compare two wetlands in the Lake George watershed in the Town of Lake George, NY, located in the Adirondack Mountains. These two wetlands are known to be experiencing contrasting levels of anthropogenic impact (Sutherland et al., 1983; Boylen et al., 2009). Traditional whole community assessment and FQA were used, as well as more specific assessments of plant morphology and tissue chemistry. We hypothesized that not only will the wetland plant communities at these two wetlands be different, but also that specific plants common to both wetlands will have different morphologies and tissue chemistry composition. In the process of comparing these wetland ecosystems and their plant-based response to anthropogenic impact, we discuss FQA implementation and suggest supplements to this procedure for future use.

2. Materials and methods

2.1. Study sites

This study took place in two wetlands in the Lake George watershed. The first is East Brook wetland (EB), a 13-hectare freshwater marsh located in the Town of Lake George, south of the lake's southern basin (Fig. 1A). It is surrounded by a combination of urban and forested land cover. Regions of the wetland surrounded by urban land cover have limited vegetation buffer. Its human impact rank is 22 on a scale of 1–24 (Lopez and Fennessy, 2002). The second is Northwest Bay wetland (NWB), a 22-hectare freshwater marsh located approximately halfway up the 32-mile lake, on the western side in the Town of Bolton (Fig. 1B). It is surrounded by forested land cover and is considered to be a pristine system. Its only notable human impact is that the central channel through the wetland was dredged to increase depth for the occasional boat to pass through. Its human impact rank is 2 on a scale of 1–24 (Lopez and Fennessy, 2002).

2.2. Water collection and analysis

Two liters of surface water were collected from the inlet and outlet of both wetlands monthly from September 2011 to November 2013, excluding winter months when sites were frozen over. All water samples were collected according to methods derived from United States Geological Survey (USGS) standard practices (U.S. Geological Survey, 2006). Duplicate samples were collected randomly during each collection event in order to corroborate sampling technique. Samples were stored and processed according to the methods of the USGS National Water Quality Assessment Program (Shelton, 1994). The following chemical and physical analytes were measured: pH, conductivity ($\mu\text{S cm}^{-1}$),

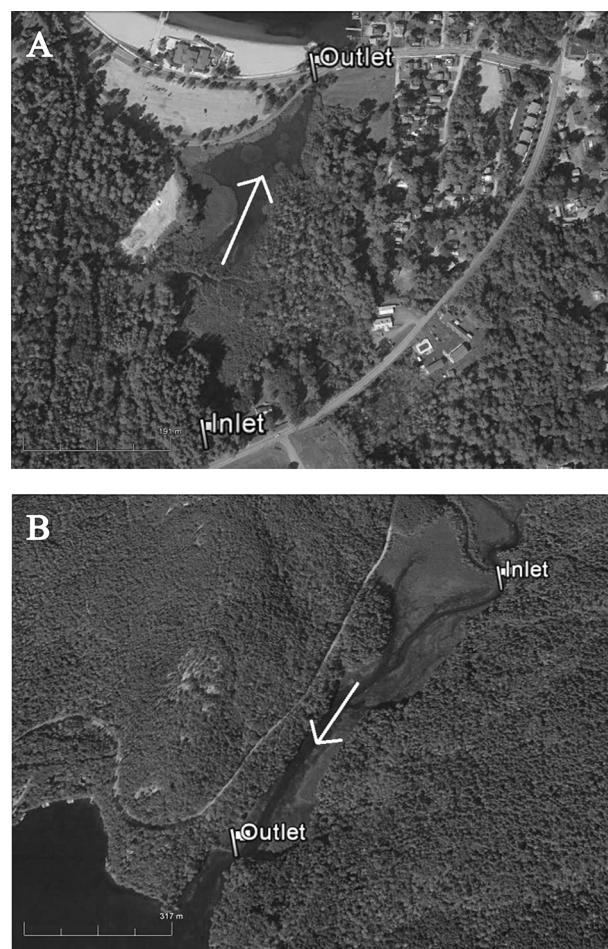


Fig. 1. Satellite images of East Brook wetland (EB) (A) and Northwest Bay wetland (NWB) (B). Flags mark inlets and outlets where water samples were collected. Arrows depict direction of water flow (Google Inc., 2013).

dissolved oxygen (mg l^{-1}), total nitrogen (mg l^{-1}), nitrate (mg l^{-1}), ammonium ($\mu\text{g l}^{-1}$), total phosphorus ($\mu\text{g l}^{-1}$), soluble reactive phosphorus ($\mu\text{g l}^{-1}$), dissolved organic carbon ($\mu\text{g/L}$), fluoride (mg l^{-1}), chloride (mg l^{-1}), sulfate (mg l^{-1}), and total suspended solids (mg l^{-1}). All measurements were taken using standard methods (Clesceri et al., 1989). Water chemistry data were compiled using Microsoft® Excel (Microsoft Corporation, 2010). Analyses of variance (ANOVA) with Bonferroni post hoc tests were performed in order to determine spatial differences between water chemistry means using SigmaPlot 11.0 (Systat Software, Inc© 2008). The use of the term “significant” indicates that the a priori p -value of 0.05 was met or exceeded.

2.3. Vegetation surveys

Vegetation communities were assessed using a line transect method in July of 2011 and June of 2012 (Anderson et al., 1979). In July of 2011, five and seven 20-meter transects were used at random locations throughout EB and NWB, respectively. Transects were placed along a vegetation gradient, with submerged aquatic vegetation at the beginning of the transect and terrestrial vegetation at the end. While the vegetation gradient was not always the same length from transect to transect, 20-meters was always sufficient to capture all wetland vegetation types from submerged to terrestrial. Transects did not enter forested areas. Every other meter, a $1\text{ m} \times 1\text{ m}$ was placed and all plants within the square were identified to species level and percent cover was estimated

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