J. Great Lakes Res. 33:366–380
Internat. Assoc. Great Lakes Res., 2007

Vegetation Change in Great Lakes Coastal Wetlands: Deviation from the Historical Cycle

Christin B. Frieswyk[†] and Joy B. Zedler[*]

Department of Botany
University of Wisconsin-Madison
430 Lincoln Dr., Madison, Wisconsin 53706

ABSTRACT. *Water-level change is integral to the structure and function of Great Lakes coastal wetlands, and many studies document predictable relationships between vegetation and water level. However, anthropogenic stressors, such as invasive species, land-use change, and water-level stabilization, interact to shift the historical cycle (of native vegetation migration up- and down-slope) toward dominance by invasive* Typha *species. Knowing from earlier studies that water-level stabilization alters the historical vegetation cycle, we asked if similar shifts can occur where water levels are not stabilized. Using historical aerial photographs of three coastal wetlands (in Lake Michigan's Green Bay, Wisconsin), we determined that habitat dominated by* Typha *species has expanded to eliminate wet meadow habitat. Between 1974 and 1992, linear regressions showed strong, significant relationships of both meadow area ($R^2 \geq 0.894$; $p < 0.02$) and marsh area ($R^2 \geq 0.784$; $p < 0.05$) to water level in all three wetlands. In 2000, meadow area was below that predicted by the historical pattern due to the landward advance of marsh habitat during a year of decreasing water levels. In the same period, land use in the wetland watersheds converted from agriculture to urban. Urbanization and the replacement of native* Typha *latifolia by the invasive hybrid* Typha *xglauca may have overwhelmed the beneficial impact of water-level fluctuation. The documentation of vegetation shifts, as herein, is an essential step in the process of preserving and restoring ecological integrity.*

INDEX WORDS: *Historical cycle, Typha, Great Lakes, wetlands, aerial photographs.*

INTRODUCTION

Coastal wetlands of the Laurentian Great Lakes exemplify the integral role of water-level change in wetland structure and function (Planck 1993, Wilcox *et al.* 2005). High water levels renew structural complexity, restrict the advance of trees and shrubs, and keep the abundance of aggressive species in check (Keddy and Reznicek 1986, Planck 1993, Wilcox 2004). Low levels maintain patchiness, allow for the expansion of wet meadow areas, and renew the seed bank (Keddy and Reznicek 1986, Gottgens *et al.* 1998, Wilcox 2004, Wilcox *et al.* 2005). In fact, relationships between vegetation area and water level are quite predictable (Lyon and Drobney 1984, Williams and Lyon 1997, Chow-Fraser *et al.* 1998, Gottgens *et al.* 1998). Four habitat types of Great Lakes coastal wetlands, shrub-carr, wet meadow, marsh, and aquatic (Harris *et al.* 1981, Kelley *et al.* 1984), also change in amount, kind and proportion (Guntenspergen 1985). In this "shifting mosaic" (Wilcox 2004), species and habitat types die back and reinvade based on their water depth affinities, with each type expanding as it moves lakeward (van der Valk 1981, Keddy and Reznicek 1986).

Water-level stabilization disrupts the historical cycle and is held responsible for promoting aggressive species (Wilcox 1993, Herrick and Wolf 2005). It converts formerly diverse, structurally complex wetlands to large areas of only a few species (Keddy and Reznicek 1986, Minc and Albert 1998) by eliminating the high and low water levels important to wetland regeneration, changing competitive interactions among plant species (Shay *et al.* 1999), and increasing phosphorus availability (Richardson and Vepraskas 2000, Boers 2006). For example, *Typha*-dominated habitat increased, displacing wet meadow habitat, in Lake Ontario coastal wetlands

[*]Corresponding author. E-mail: jbzedler@wisc.edu
[†]Current Address: Cleveland Botanical Garden, 11030 East Blvd., Cleveland, OH 44106

following the start of water-level regulation (Wilcox *et al.* 2005).

In addition to water-level stabilization, several other anthropogenic stresses have the potential to transform the historical cycle (Patterson and Whillans 1985, Chow-Fraser *et al.* 1998, Gottgens *et al.* 1998). These include land-use change, the introduction of invasive species, other hydrological alterations, and changes in sediment and nutrient loads, all of which can alter competitive relationships (Galatowitsch *et al.* 1999, Weller *et al.* 2003, Zedler and Kercher 2004).

We observed from Landsat TM imagery (30-m pixel) a vegetative trend similar to what occurs with stabilized water levels in a Green Bay, Lake Michigan wetland with natural water-level fluctuation. That is, wet meadow habitat was smaller relative to *Typha*-dominated marsh habitat in 2001 under low water levels than it was in 1994 when water levels were higher. In this interval, water level rose, peaking in 1997, then decreased, falling below the 1994 level by 1999. While some lag time between water-level change and vegetative response is expected, smaller meadow area at a lower water level was contrary to our expectation and prompted us to undertake a more detailed investigation of three Green Bay wetlands using aerial photographs. We examined the relationship of marsh and wet meadow habitat to water level to determine if the historical vegetation cycle has changed despite naturally fluctuating water levels. We hypothesized that (a) historically, both marsh and wet meadow habitats expanded predictably lakeward as water levels fell and wetland area increased, (b) during the most recent water level decline, marsh habitat area was greater and wet meadow habitat area was less than predicted by the historical trend, and (c) marsh habitat continued to expand landward during the most recent water level decline, contrary to the historical pattern.

METHODS

Study Area

We chose three wetlands and their associated upland areas along the western shore of Green Bay in Brown County, Wisconsin, to represent anthropogenically stressed, embayment wetlands of the Laurentian Great Lakes (Fig. 1). Atkinson Marsh (44°34′00″N/88°02′30″W), Peter's Marsh (44°35′15″N/88°01′30″W), and Long Tail Marsh (44°37′30″N/88°00′45″W) are all directly influenced by natural water-level changes in Lake Michigan. Each one contains areas of shrub-carr dominated by *Salix* and *Cornus* spp., wet meadow dominated by *Carex* spp. and *Calamagrostis canadensis* (Michx.) Beauv., shallow marsh dominated by *Typha* spp., and deep marsh dominated by *Nymphaea odorata* Ait. and *Sagittaria* spp. or newly exposed sand flats dominated by *Juncus* spp. and *Schoenoplectus* spp. All were described by Herdendorf *et al.* (1981) as having low topography, direct exchange with the waters of Green Bay via seiche activity, important wildlife habitat, and surrounding areas undergoing urbanization. Prior to 1973, a chain of islands known as the Cat Islands stretched along the Green Bay coast offshore from Peter's Marsh and Atkinson Marsh. These islands were destroyed by rising water levels and severe storms in the early 1970s, reducing the area suitable for emergent vegetation and likely allowing greater impacts of waves on wetland shores.

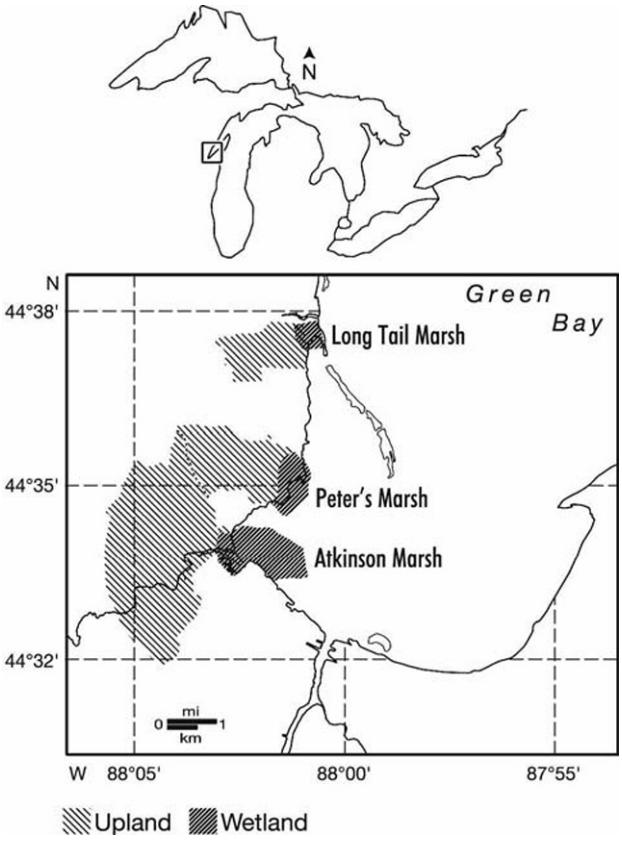

FIG. 1. Location of study sites along the coast of Green Bay, Lake Michigan in Brown County, Wisconsin, USA.