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Typha invasion associated with reduced aquatic macroinvertebrate abundance in northern Lake Huron coastal wetlands

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ABSTRACT

Aquatic macroinvertebrates are a critical component of wetland nutrient cycling and food webs, with many fish and wildlife species depending upon them as food resources; but little is known about how invasion by dominant macrophytes may alter community dynamics. We examined the impacts of *Typha* invasion on aquatic macroinvertebrate communities in three northern Great Lakes coastal wetlands by comparing community composition between stands of native emergent marsh and those dominated by invasive *Typha*. *Typha* invaded zones were associated with shallower and cooler water than native emergent zones, and we detected decreased aquatic macroinvertebrate density and biomass in invaded zones. After accounting for the positive effect of plant species richness on macroinvertebrate abundance, we observed *Typha* invaded coastal zones had less total macroinvertebrate and insect biomass than native zones across all levels of plant richness. Our results suggest that *Typha* invasion reduces habitat quality for aquatic macroinvertebrates by homogenizing structural diversity and reducing water temperatures, which in turn may negatively impact predatory organisms by decreasing food resources. We recommend experimental tests of *Typha* management treatments to identify techniques that may promote structurally diverse and biologically rich Great Lakes coastal wetlands.

Introduction

Wetland macroinvertebrates play a crucial role in wetland ecosystems, linking primary producers and secondary consumers. Many wildlife species, including fish (Cvetkovic et al., 2010; Jude and Pappas, 1992), marsh breeding birds (de Szalay and Resh, 1997; Krull, 1979) and herpetofauna (Anderson et al., 1999; Wieten et al., 2012) depend upon wetlands for habitat and food resources during some portion of their life cycle. Wetland invertebrates are an especially important food resource for migratory bird species during spring and fall migrations (Anderson and Smith, 2000; Kostecke et al., 2005), and breeding bird habitat is positively correlated with invertebrate richness (Findlay et al., 2002). The growing dominance of invasive plants in wetlands, (Zedler and Kercher, 2004), however, can alter aquatic macroinvertebrate community structure and impact desirable wildlife species at higher trophic levels (Schultz and Dibble, 2012).

The mechanisms by which invasive plants can impact macroinvertebrate communities are complex, with invasion resulting in negative (Feldman, 2001; Stiers et al., 2011; Toft et al., 2003), positive (Phillips, 2008; Strayer et al., 2003), or non-detectable impacts (Cattaneo et al., 1998, Gardner et al., 2001). Plant traits that determine the rates of ecosystem processes such as biomass production, photosynthesis, and decomposition may be important predictors in determining how macrophyte invasion will impact macroinvertebrate communities (Schultz and Dibble, 2012). Increased biomass production associated with macrophyte invasion can decrease light penetration and water temperatures (Lishawa et al., 2015; Rose and Crumpton, 1996) which could negatively impact aquatic macroinvertebrate development and survival by limiting metabolic processes. Macrophyte invasion could benefit macroinvertebrate communities if enhanced rates of photosynthesis increased dissolved oxygen in the water column and/or if greater litter inputs provided appropriate detrital substrates (Strayer et al., 2003; Phillips, 2008). However, inputs associated with productive invaders can create dense mats of decaying vegetation that can promote anoxic conditions and reduce dissolved oxygen concentrations and reduce macroinvertebrate densities (Stiers et al., 2011). Macrophyte invasion that both increases plant biomass and habitat complexity can be beneficial to macroinvertebrate communities, as has been found for several invasive aquatic plants with highly dissected leaves or roots (e.g.: *Hydrilla verticillata*, *Myriophyllum spicatum*; *Trapa natans*; reviewed by Schultz and Dibble, 2012). However, if invasion reduces habitat complexity by displacing native macrophytes with desirable features, then invertebrate communities may be negatively impacted

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(Houston and Duivenvoorden, 2002). Ecological theory predicts that greater plant diversity should increase the richness of higher trophic levels, as a diverse plant community should provide resources for a greater number of species (Hutchinson, 1959); this idea is supported by several experimental studies that have detected positive relationships between plant and insect species richness in grassland communities (Haddad et al., 2009; Knops et al., 1999; Siemann et al., 1998).

Typha × *glauca* (hereafter *Typha*) is an aggressive hybrid cattail that occurs where native *Typha latifolia* and non-native *Typha angustifolia* populations overlap and cross pollinate (Smith, 1987). This problematic invader is especially abundant in the Great Lakes (Freeland et al., 2013) and prairie pothole regions (Seabloom and van der Valk, 2003) of North America, though accurate field identification of the hybrid is difficult because of introgression within the genus (Kirk et al., 2011; Travis et al., 2010, 2011; Witztum and Wayne, 2015). *Typha* can expand rapidly (e.g., up to 4-m in clone diameter per year; Boers and Zedler, 2008) in response to nutrient enrichment (Woo and Zedler, 2002) and altered hydroperiods (Hall and Zedler, 2010; Lishawa et al., 2010), often resulting in large monotypic stands. The spread of dense *Typha* clones throughout the Great Lakes region (Galatowitsch et al., 1999; Lishawa et al., 2010; Tulbure et al., 2007) has altered coastal wetland ecosystems by increasing plant biomass and litter production, decreasing native plant species diversity (Frieswyk and Zedler, 2006; Mitchell et al., 2011; Tuchman et al., 2009), altering nutrient cycling regimes (Farrer and Goldberg, 2009; Larkin et al., 2012; Lishawa et al., 2014), decreasing light penetration (Lishawa et al., 2015), and buffering temperatures (Larkin et al., 2011).

The drastic biotic and abiotic alterations associated with *Typha* invasion could affect wetland macroinvertebrate communities through a variety of mechanisms, though we are unaware of any studies that have directly examined the impact of invasive *Typha* on wetland macroinvertebrate communities in the upper Great Lakes. Our objective was to determine how *Typha* invasion affects aquatic macroinvertebrate communities within northern Lake Huron coastal wetlands, an area of the US Great Lakes harboring the highest quality remaining coastal wetlands (Uzarski et al. unpublished data) and where *Typha* is increasingly common and ecologically detrimental (Lishawa et al., 2010). We surveyed aquatic macroinvertebrate communities in three recently invaded coastal wetlands, comparing native emergent marsh areas to *Typha* invaded zones. We hypothesized that areas invaded by *Typha* would support less aquatic macroinvertebrate biomass, density and diversity than native zones due to dense litter accumulations that decrease water temperature, dissolved oxygen concentrations, and structural heterogeneity. We also predicted that aquatic macroinvertebrate biomass, density, and diversity would be correlated with plant richness, as a diversity of resources should support a variety of invertebrates.

Methods

Study sites

To examine the effects of *Typha* on aquatic macroinvertebrate communities in northern Great Lakes coastal wetlands, we chose three wetlands that have portions of their emergent marsh habitat dominated by nearly monotypic stands of *Typha* and adjacent native plant dominated emergent marsh. All three sites are open embayment freshwater coastal wetlands; Cheboygan (N 45.84747, W 84.47706) and Cedarville (N 45.99514, W 84.36267) Marshes are located on the coast of Lake Huron in northern Michigan (U.S.), and St. Ignace Marsh (N 45.84747, W 84.74465) is located on the Straits of Mackinac (Fig. 1). Due to regional proximity (all within 40 km), the three wetlands have similar climates, plant assemblages, and sediments (Albert et al., 2005).

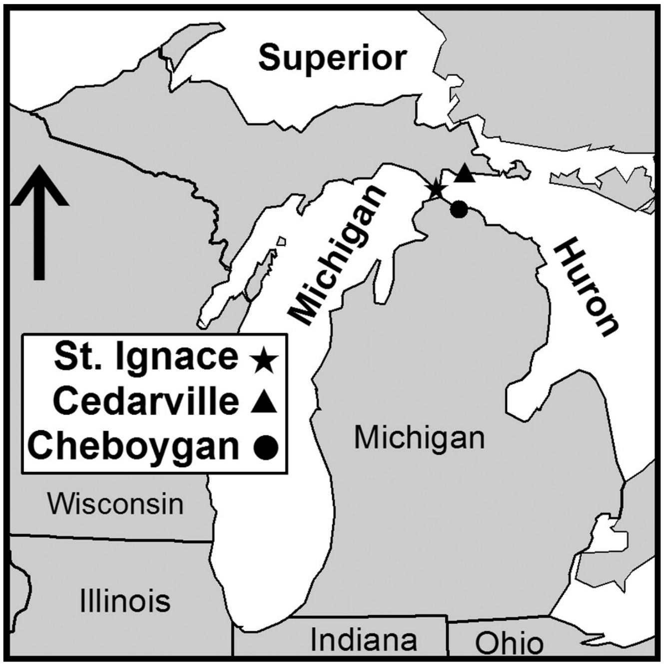

Fig. 1. Three northern Lake Huron coastal wetlands were sampled in 2011 to characterize aquatic macroinvertebrate communities in native and *Typha* invaded emergent marshes.

Using GIS and aerial photography, we delineated *Typha* and native emergent marsh zones, and visually confirmed via ground truthing that *Typha* invaded zones were nearly monotypic *Typha* stands, and that native emergent zones were dominated by native wetland plant species (few to no *Typha* stems). To reduce the confounding effects of water depth, we targeted areas that had comparable water depths. This resulted in sampling locations that were relatively recent *Typha* invasions, most likely <20 years old, as *Typha* tends to be denser and more abundant in protected areas farther from open water (Lishawa et al., 2010). We randomly located three plots in each vegetation zone (*Typha*, native), for a total of 18 plots (3 sites × 2 vegetation zones × 3 plots). Aquatic macroinvertebrates, vegetation, and abiotic variables were sampled from these plots during the peak of the 2011 growing season.

Aquatic macroinvertebrate sample collection

We sampled each of the 18 plots in June, July, and August 2011. During each sampling campaign, we randomly placed a 1 m^2 quadrat frame within a 5-m radius of the plot center and collected an invertebrate sample using the stovepipe collection method (Gathman and Burton, 2011). We forced a 14.5-cm diameter aluminum stovepipe through the water column and approximately 5 cm into the sediments. Once the stovepipe was in place, we removed any loose vegetation and placed it into a 300-μm sieve. We then agitated the water within the stovepipe to loosen the top of the sediment (2–3 cm) and used a syphon-pump to extract the water and invertebrates out of the pipe and into the sieve. To standardize biomass and species richness calculations, each stovepipe was pumped 100 times, regardless of water depth; we established that 100 total pumps was sufficient to extract the majority of invertebrates within the stovepipe. If fewer than 100 pumps emptied the stovepipe, we allowed water to seep back into the stovepipe before continuing. After the invertebrates were pumped into the sieve, we transferred them and any sediment not passing through the sieve into collection jars and transported them to the laboratory in a cooler.

We processed the stovepipe samples within 24 h of collection by rinsing them through a 300-μm sieve to decrease the amount of fine particulate matter in the sample. We then placed each sample into a white enamel pan and picked out all visible macroinvertebrates.

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