FINAL REPORT

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Disturbance, Vegetation, and Floristic Diversity in a Lake Erie Coastal Wetland

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Abstract

Development activities in Lake Erie's Western Basin have disrupted critical marsh-lake disturbance patterns. As a result, native plant species richness has waned while aggressive species abundance has escalated. In 1992, the substrate of a 0.6 hectare section of a diked marsh in East Harbor was mechanically disturbed to activate the seed bank and the section reconnected to the harbor. Species richness increased by at most 12% in the three years following disturbance. The number of species listed as rare or endangered in Ohio also increased from seven to nine. The abundance of aggressive species, particularly *Phragmites australis* (Cav.) Trin ex Steudel, was significantly curtailed though aggressor richness remained unchanged. Extant vegetation data obtained in 1998 and 1999 indicate, however, that species richness and aggressive species abundance have returned to pre-disturbance levels. Cumulatively, 37% of the initial post-disturbance, extant species and 69% of the current extant species were represented in seed bank analyses. Six seed bank species were aggressive species including *Phragmites australis*. Seven species were state-listed plants. While the initial disturbance activated the seed bank, subsequent hydrologic stress has been insufficient or too infrequent to maintain seed stores and control aggressive species.

Introduction

Historically, the freshwater marshes of Lake Erie's Western Basin have been considered exceptionally diverse ecosystems harboring a number of rare and endangered plant species. Maintenance of floristic diversity within these wetlands has been attributed to the oscillating environmental conditions typical of Lake Erie (Stuckey, 1988, Bedford 1992). Long- and short-term water level fluctuations, storm events, wave exposure, and seiches have created a patchy community structure. These forces also have altered the landscape via sediment deposition and removal, and have selectively activated the seed bank.

Dredging, diking and development activities along Lake Erie's shoreline in the past 50 years have altered or eliminated marsh-lake interactions. With the local disturbance regime modified, aggressive plant species (e.g.—*Phragmites australis* (Cav.) Trin ex Steudel) have formed monodominant stands in many formerly diverse marshes (Galatowitsch et al. 1999). The diverse seed banks associated with these diverse wetland plant communities also can be adversely affected (Pederson and van der Valk 1984). Prolonged occupation of wetland sites by competitive dominants prevents seed bank renewal by desirable species, augments the seed bank with aggressive species' propagules, and allows for the continued decay and predation of the buried seeds of native species (Leck 1989). By restoring or imitating the natural disturbance regime, however, historic plant populations and community structure can be re-established (Brown and Bedford 1997) and aggressive species controlled (Keddy and Reznicek 1982).

In 1992, the substrate of a 0.6 hectare section of a 6.4 hectare diked marsh was mechanically disturbed to activate the seed bank and the section reconnected to the harbor via a culvert. Recently plans have been made to restore the entirety of the diked marsh in a similar fashion. To assess the long-term success of such human-induced disturbance activities, we surveyed the extant and potential vegetation of the mechanically disturbed area seven years post-disturbance. This paper compares pre- and post-disturbance vegetation data collected by McCormac (1993) with extant and seed bank data collected throughout the entirety of the diked marsh in 1998 and 1999.

Methods

Site Location

- The study site is located within East Harbor State Park, Ohio, just north of Sandusky Bay on Lake Erie (41 33' 45" N, 82 48' W).

Vegetation Survey

- Vegetation was surveyed in the spring and fall of 1998 for the entire site along transects randomly placed within 75 m intervals on an established baseline.
- The 1999 transects were delineated every 18 m along the same baseline.
- A 1 m^2 quadrat was assessed for species composition, number of stems, percent cover, and average stem height every 25 m along each transect.

Seed Bank Study

- Soil samples from the top 5 cm were collected randomly in 1998 and 1999.
- Each sample was homogenized manually.
- A 2.0 cm layer of each sample was placed in each of four 17.5 cm x 12.5 cm x 6 cm trays containing 3.5 cm of sterilized sand.
- Two replicates of each sample including controls were exposed to both inundated (10 cm) and saturated (2 cm) conditions.
- Samples were exposed to standard greenhouse conditions and water levels maintained.
- Individual plants were counted and identified over a six-month period.

Results

Vegetation Survey

- In the three years following disturbance, species richness increased by at most 12%.
- The abundance of aggressive species, particularly *P. australis*, was greatly reduced.
- By 1998 and 1999, however, species richness declined below pre-disturbance levels.
- The number of state-listed species peaked in 1994 but returned to pre-disturbance richness and composition in 1998 and 1999.
- Aggressive species richness continued to decline in 1998 and 1999 (**Figures 1 and 2**).
- *P. australis* and *Phalaris arundinacea* L., both considered aggressive species, dominated most quadrats in recent studies.
- Aggressive species found in the disturbance site accounted for less than half of the aggressive species richness for the marsh.
- Similarly, not all state-listed species present in the marsh were found in the disturbance site.
- The percentage of wetland indicator species declined from a high of 74% in 1993 to 66% in 1999, approaching pre-disturbance levels (60%).

Seed Bank Study

- Seed bank species richness for the disturbed site exceeded extant species richness by 52% in 1998 (**Figures 1 and 2**).
- Eighty-two percent of all seed bank species found in the marsh in 1998 were present in the disturbance site seed bank.
- In 1999, seed bank species in the disturbed site accounted for 61% of the extant species present and 77% of all seed bank species found in the marsh.
- Aggressive species richness for the disturbance site was greater for the seed bank than for the standing vegetation in 1998 but equal in 1999.
- Similarly, state-listed species richness in the disturbance site was greater for the seed bank than for the extant vegetation in 1998.
- The number of state-listed species in the disturbance site seed bank was equivalent to the number of state-listed species found in the extant vegetation in 1999.
- All state-listed species found in the marsh were present in the disturbance site seed bank.
- Seventy-eight and 86% of the seed bank species in the disturbance site in 1998 and 1999, respectively, were wetland indicator species.

Discussion

McCormac (1993) showed that by replicating natural substrate disturbance in a Lake Erie coastal marsh overall plant species richness could be increased by activating viable seeds stored in the soil. Simultaneously, the abundance of aggressive species could be reduced. While effective in the short-term, the long-term efficacy of such a practice needs to be monitored if it is to be used as a wetland restoration tool. Our investigation of the disturbance site seven years post-disturbance suggests that 1) species richness for both state-listed species and aggressive species has declined to pre-disturbance levels; and 2) aggressive species, particularly *P. australis*, a clonal, dominant plant, are again dominating the marsh plant community.

While McCormac (1993) noted the steady return of *P. australis* in the three years following the disturbance, results from 1998 and 1999 reflect a rapid expansion of this aggressive species. The spread of *P. australis* throughout the site has been exacerbated by the dramatic decline in Lake levels in 1999. While Lake Erie water levels have been relatively high the past 30 years, the recent decline and its continuation have provided ideal conditions for the expansion of *P. australis* into formerly inundated sites too deep for propagation. Simultaneously, total species richness for the site has dropped below pre-disturbance numbers. Both extant and seed bank communities have been negatively affected. Rare and endangered species continue to persist in the seed bank, but an equal number of aggressive species also can be found in the seed bank.

While the initial disturbance activated the seed bank, subsequent hydrologic stress has been insufficient or too infrequent to maintain seed stores and control aggressive species. The ecological stress that exists has been unidirectional, allowing for adaptation by aggressive species and subsequent homogenization of the wetland plant community. Though it is believed that hydrodynamic change plays a part in fostering the diversity found in Lake Erie wetlands, Keddy and Reznicek (1986) emphasized that our understanding of the amplitude and frequency of change required to maximize species diversity for most ecosystem settings is poor. Appropriate levels of disturbance will vary based on the history of the ecosystem being investigated and the plant species present. Any efforts at restoration must include, therefore, a working knowledge of the historical disturbance regime and an understanding of the life history traits of the plant community members, both potential and extant. This investigation indicates that human-induced disturbance as a means of wetland restoration requires long-term monitoring and perhaps multiple disturbance events.

Benefits and Dissemination

The relationship between disturbance and plant community productivity and diversity is poorly understood, particularly in wetland ecosystems. It is believed that intermediate levels of disturbance to which plant species have become adapted over time foster diversity while limiting the dominance of aggressive species. Given the wide spread distribution of aggressive, invasive plants throughout Lake Erie wetlands, an

understanding of this relationship may prove beneficial to natural resource managers confronted with such concerns. This project has addressed some of these key issues in the context of the East Harbor wetland plant communities and the associated disturbance regime. As it pertains to East Harbor, the long-term control of such species as *P. australis* may benefit not only the wetland plant community but also the Park and its visitors through future educational and recreational activities.

Funding obtained from this grant was intended to cover start-up costs associated with the dissertation research of one doctoral student. Upon completion of the dissertation, it is anticipated that papers will be submitted to the *Wetlands*, *Aquatic Botany*, and other appropriate journals for peer review. One presentation of these data already was given in August 2000 at the Millennium Wetland Event hosted by the Society of Wetland Scientists, the International Peat Congress, the International Association of Ecology, and the International Mire Conservation Group.

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Figure 1. Extant and Seed Bank Species Richness for the East Harbor Disturbance Site

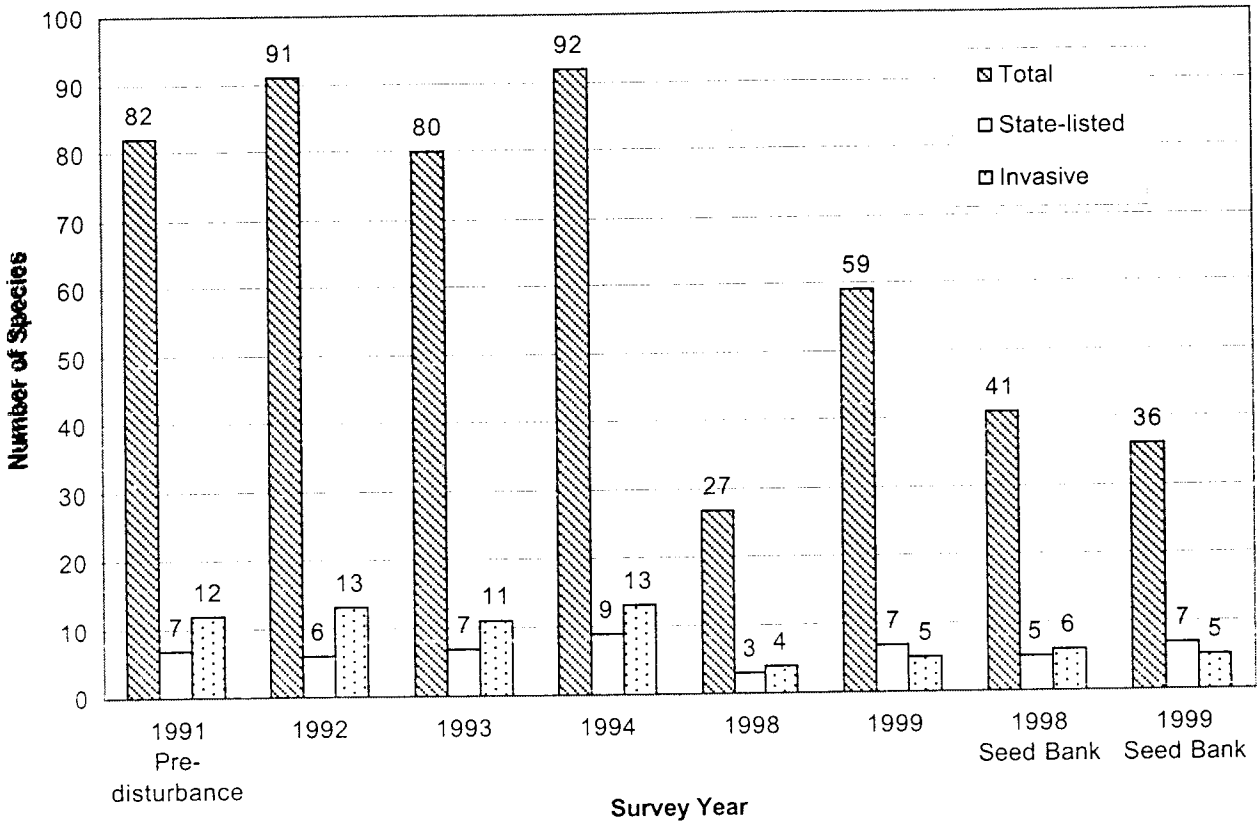

Figure 2. Extant and Seed Bank Species Richness for the Entire East Harbor Marsh