J. Aquat. Plant Manage. 39: 136-139

NOTES

Dynamics of a Pioneer Population of Eurasian Watermilfoil (*Myriophyllum spicatum* L.) in a Shallow Lake Erie Wetland

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INTRODUCTION

Eurasian watermilfoil (*Myriophyllum spicatum* L.) is an exotic, highly invasive submersed plant believed to have been introduced from Eurasia into North America in the 1940s, and has now spread throughout a majority of the continent's temperate zone (Couch and Nelson 1985, Grace and Wetzel 1978, Smith and Barko 1990). The plant is characterized by its rapid growth, ability to effectively out compete other submersed species, and dispersal through stem fragmentation allows it to readily invade and colonize new habitats (Madsen and Smith 1997, Smith and Barko 1990). The result has been the formation of extensive monotypic stands of this plant and a decline in native plant populations (Lillie 1990, Madsen et al. 1991, Smith and Barko 1990).

Couch and Nelson (1985) report the first record of Eurasian watermilfoil in Lake Erie at Put-In-Bay Harbor, Ohio, in 1949. The plant is generally not considered a problem in the Great Lakes and associated wetlands, although it has caused significant problems in the watershed and has been reported in the St. Clair-Detroit River System (Mills et al. 1993). Overall, its distribution and abundance are not well documented, and its associated impact to the existing biota unknown.

The appearance of Eurasian watermilfoil in the Old Woman Creek National Estuarine Research Reserve (OWC) in Lake Erie in 1992 (Francko and Whyte 1994), presented an excellent opportunity to monitor a potential invasion by this submersed macrophyte and any concurrent change in existing plant community structure. Although Stuckey (1988) documents Eurasian watermilfoil in Western and Central Lake Erie, a literature survey and review of specimen sheets from herbaria at Miami University (Oxford, Ohio), Ohio State University (Columbus, Ohio), and Kent State University (Kent, Ohio) provide strong evidence that the 1992 discovery was the first documented occurrence of the plant in OWC. Perhaps the most significant aspect of this note is the documentation of the apparent failure of Eurasian watermilfoil to become the dominant submersed macrophyte in a natural freshwater system.

MATERIALS AND METHODS

Study Site. The Old Woman Creek National Estuarine Research Reserve (OWC) is situated on the eastern edge of Lake Erie's western basin, in Erie County, Ohio, and represents one of the few remaining undeveloped coastal wetlands along the south shore of Lake Erie. Classified as a freshwater estuary, this 56-hectare shallow wetland is characterized by its drowned river mouth as it enters Lake Erie (Herdendorf 1990). A sand-barrier beach and adjacent lake levels control wetland water levels. Water depths in OWC average less than 50 cm but can increase to more than 1 m in response to storm events from the watershed and Lake Erie storm surges. Dominant macrophytes include the floating-leaf plant American water lotus (*Nelumbo lutea* L.), which covers approximately 40 percent of the wetland (Whyte et al. 1997) and the submersed species sago pondweed (*Potamogeton pectinatus* L.) and coontail (*Ceratophyllum demersum* L.), which are concentrated in the northwest embayment of the lower estuary (Whyte 1996).

Vegetation Sampling Methods. Specific sampling efforts for Eurasian watermilfoil were part of a larger study of the OWC flora for the period 1993-1995, and are reported in Whyte (1996). Subsequent monitoring of the wetland and documentation of the presence for Eurasian watermilfoil was also done in 1996 and 1997. Voucher specimens were collected for all reported species including Eurasian watermilfoil, and were deposited in the Willard Sherman Turrell Herbarium of Miami University, Oxford, Ohio.

Quantitative sampling of aquatic vegetation in the northwest embayment and in the lagoon behind the barrier-beach was done in August of each year of the study period utilizing standard transect sampling procedures for aquatic and wetland vegetation (as described by Titus 1993). Sampling was done along 13 equally spaced transects placed perpendicular to the shore extending into the open water. The initial transect position was randomly determined within a 50 meter segment of shoreline. This method was used in order to map the existing vegetation and to document change in species distribution during the study period. Species pres-

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ence was recorded in 0.25 m^2 quadrats placed every three meters along each transect.

In addition, the entire wetland was surveyed by canoe using direct visual observations and systematic raking of the open water. Raking was also used in the lagoon along the established transects. The use of an extendable rake, pulled through the water, enhanced the detection of any submersed plants, which were often not visible in the highly turbid water. The presence and location of floating vegetative fragments were also recorded. The sand-barrier beach was periodically monitored to detect the movement of Eurasian watermilfoil from Lake Erie into the wetland. The presence of Eurasian watermilfoil was recorded on a base map, marking the location of Eurasian watermilfoil relative to the established line transects. In addition all locations were marked in the estuary for follow-up observations.

RESULTS AND DISCUSSION

All documented areas of Eurasian watermilfoil were found north of Star Island, and generally in the northwest embayment and the lagoon behind the barrier beach (Figure 1). The pioneer population discovered in 1992, failed to reappear in subsequent years. A second population was discovered north of State Route 6 in 1993, but also failed to return in 1994. Except for occasional vegetative fragments found floating in the northwest embayment, in the lagoon behind the barrier beach, and along the immediate shore of the mouth, Eurasian watermilfoil was absent from the estuary in 1994. In 1995, 21 separate sites, each containing one to several plants, were found throughout the northwest embayment and in the lagoon behind the barrier beach. In 1996, only two sites containing one to three plants were found, each adjacent to the southwest shore in the northwest embayment. Three sampling events in the summer of 1997 found no established plants. No plants were found in any of the sample plots along the established transects for the entire period of the study, although plants were occasionally found growing in the immediate vicinity of the transect lines.

Eurasian watermilfoil, including vegetative fragments, has only been observed north of Star Island, suggesting that pioneer populations have periodically invaded the estuary by moving through an open barrier beach. Seiche events on Lake Erie resulting from wind and wave activity may facilitate the movement of plant fragments into the wetland. Periodic inspection of the OWC barrier beach between 1993 and 1996 often revealed plant fragments washed onto the beach.

The importance of the sand-barrier beach as a mechanism regulating estuary dynamics has been discussed in a number of studies (e.g. Klarer 1988, Herdendorf and Hume 1991) and we believe it may also be an important factor facilitating the movement of Eurasian watermilfoil fragments into OWC. When the barrier beach is open, wind and resulting seiche activity in the lake causes movement of lake water into the estuary. Long-term data indicate the period for which the mouth is open and closed approximate one another (personal communication, Dave Klarer). Year-to-year variation, however, can be considerable as evidenced for the period 1993-1995 in which the mouth was open 58%, 41%, and 77% respectively (Whyte 1996). This corresponds to two observed plant sites in 1993, none in 1994, and 21 sites in 1995. If the barrier beach is an important control mechanism, then it must also be assumed that the source is Lake Erie and not the immediate watershed. The most convincing evidence for the lake as a source comes from visual observation and data: the periodic observation of fragments in the immediate vicinity of the mouth (lakeside and in the wetland) and fragments washed up on the beach; fragments found at the beach fronting Sheldon's Marsh, a coastal wetland immediately west of OWC in Huron, Ohio; and the lack of fragments or established plants observed south of Star Island. Additionally, reconnaissance trips in the OWC watershed revealed no evidence of established plants or fragments. Continued observations and data collection will be required, however, before any firm conclusions can be made regarding the role of the barrier beach and the invasion and establishment of the plant in the estuary.

The variable growth observed in OWC may also be attributable to a variety of other environmental factors including shallow water (<1 m) and periodically exposed mudflats, or dewatering of the wetland as observed in the fall and winter of 1995 (Whyte et al. 1997) and subsequent freezing of overwintering root crowns. Eurasian watermilfoil may be susceptible to freezing and subfreezing temperatures during periods of natural drawdown, exposing the plants and killing them or limiting next year's growth. Cooke et al. (1986) reviewed the use of winter drawdown as a successful technique to control Eurasian watermilfoil. Cooke (1980) suggested a minimum exposure period of three weeks to freezing temperatures to successfully restrict subsequent growth. Geiger (1983) found winter drawdown reduced the biomass of Eurasian watermilfoil. In OWC, water temperatures from January 21 through February 28, 1995 were at or below freezing for at least part of the day (personal communication, Dave Klarer). Air temperature lows for this period in OWC ranged from -7.8C to 4.4C, and the low was above freezing on only four days during this period. This suggests that conditions in the shallow nearshore environment may effectively allow the exposure of Eurasian watermilfoil to freezing. Plants located in the nearshore areas may also be susceptible to ice movement and shearing of the rootcrown and any existing overwintering above-ground portion of the plant (Smith and Barko 1990).

Two biotic interactions must also be considered—facilitation and allelopathy, the latter being a direct extension of competition. For example, the current pattern of initial establishment in the shallow nearshore zone of the lower estuary may result from free-floating fragments being driven up along the shore by wind and wave activity. Later in the growing season as American water lotus becomes established, quiet zones are created in the open water and apparently enable Eurasian watermilfoil to occupy these areas as well, a pattern which was observed in 1995. In July of 1995 numerous pockets of Eurasian watermilfoil were encountered along the immediate shoreline; however, by early- to mid-August several small patches consisting of 1-3 plants had established in the open water areas adjacent to existing beds of American water lotus. Some researchers have suggested that facilitation may play an important role in determining plant community structure in highly disturbed systems (Connell and Slayter 1977, Bertness 1989, Bertness and Shumway 1993). The extensive beds of

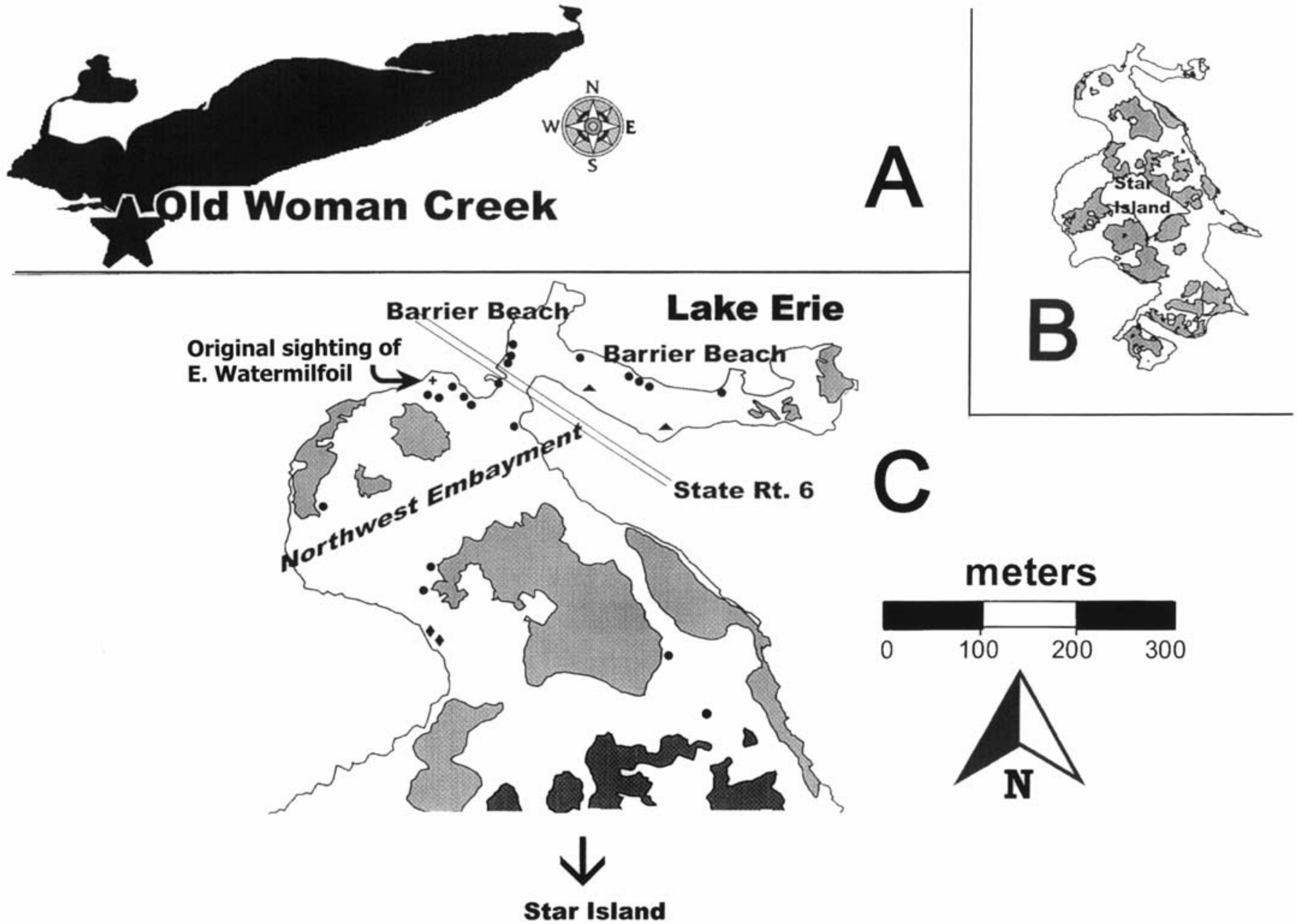

Figure 1. Observed distribution of Eurasian watermilfoil (*Myriophyllum spicatum*) in the Old Woman Creek National Estuarine Research Reserve, for the years 1992 (+), 1993 (●), 1995 (Δ), and 1996 (◆). No Eurasian watermilfoil was found in 1994 or 1997. The study site is located in the Northwest Embayment (A) of OWC (B) found along the south shore of the west basin of Lake Erie (C). Shaded areas represent monotypic stands of the floating-leaf macrophyte American water lotus (*Nelumbo lutea*).

American water lotus in OWC, may act in such a capacity by creating large areas of quiet water, allowing the vegetative fragments to settle and grow within these areas. Several of these quiet water areas in OWC were found to contain Eurasian watermilfoil, sago pondweed, leafy pondweed (*Potamogeton foliosus* Raf.), and American pondweed (*Potamogeton nodosus* Poiret.). Alternatively, Vance and Francko (1997) reported that American water lotus may produce water-soluble, quasi-allelopathic agents capable of reducing Eurasian watermilfoil growth under ecologically realistic conditions.

The physical, chemical and biological conditions of OWC and the Great Lakes coastal environment in general may affect the growth and distribution of Eurasian watermilfoil. OWC has a large surface area to depth ratio, which facilitates the resuspension of bottom sediments greatly reducing water clarity. As discussed, an open barrier beach subjects OWC to seiches and Lake Erie storm surges and also influences sediment transport and nutrient dynamics. The sediment is characterized as predominantly silts and clays and areas of high sediment organic content (Heath 1992). Turbidity in the open water may often exceed 60 NTUs suggesting macrophyte growth may be light limited. Francko and Whyte (1999) suggest that a combination of turbidity and water depth may be the most important abiotic control on macrophyte growth in OWC. We are unaware of any studies in OWC documenting nutrient limitation on macrophyte growth. Havens (1991) described OWC as a shallow hypereutrophic lake during periods that the sand-barrier beach extends across the mouth of the wetland. The eutrophic conditions characteristic of OWC including nutrient-rich substrate, low light, and high water temperatures could promote shoot elongation and extensive canopy development (Barko and Smart 1981).

Much of our knowledge regarding Eurasian watermilfoil growth dynamics comes from research and observations in relatively stable lacustrine systems. Similarly, most competition studies have used lake dynamics as the underlying assumption for these experiments. In contrast, our knowledge regarding Eurasian watermilfoil growth in dynamic and highly disturbed systems such as Great Lakes coastal wetlands and other somewhat similar coastal wetland systems along the Hudson and Chesapeake are limited to a few studies (e.g., Stevenson et al. 1993, Harley and Findlay 1994). Coastal wetland systems are subject to naturally occurring fluctuations in water levels, both long-term and seasonal. Anthropogenic impacts have also been great in these coastal areas. Additional studies, both short-term and long-term will be required to more adequately assess the role of biotic and abiotic factors in these coastal systems. The identification of the various mechanisms controlling population growth will allow the development of effective management strategies, and aid in the development and restoration of coastal wetlands and their associated plant communities.

ACKNOWLEDGMENTS

This work was supported by grants from the Ohio Sea Grant Program (R/ER-32 and R/ER-46), the Lake Erie Protection Fund (SG 98/96), and by the Department of Botany, Miami University. Sincere appreciation and thanks are given to David Klarer and the staff at the Old Woman Creek National Estuarine Research Reserve in Huron, Ohio.

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