All About

EUROPEAN WATER CLOVER

(Marsilea quadrifolia)

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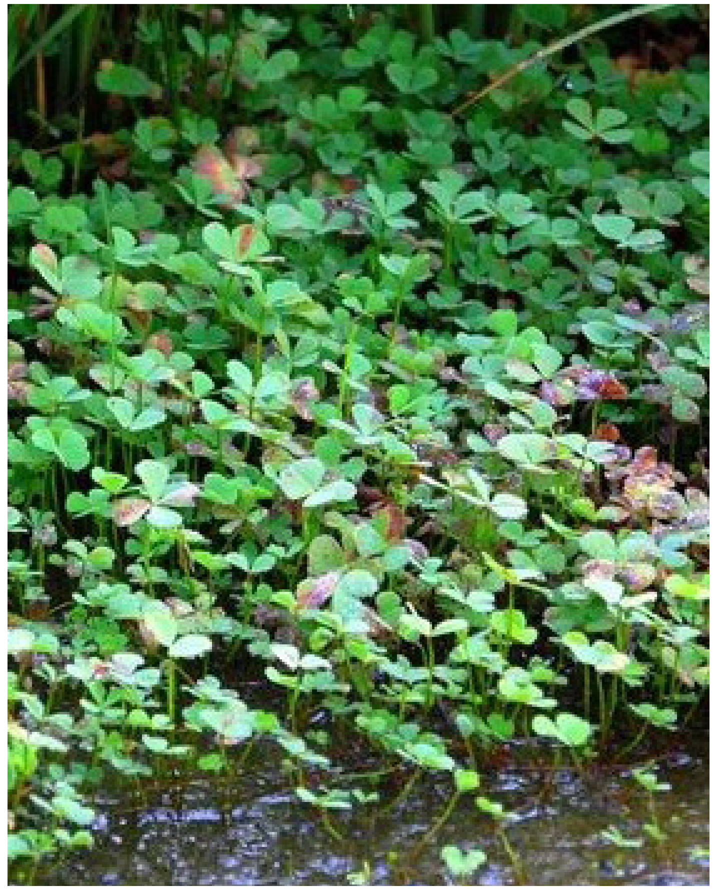

INTRODUCTION:

Invasive species threaten Michigan's freshwater ecosystems by reducing biodiversity and imposing substantial economic costs. As organisms enter ecosystems beyond their native range, a combination of life-history characteristics, physiology and prevailing environmental conditions often dictate the probability of becoming established and causing ecological and economic harm. European Water Clover (EWC), Marsilea quadrifolia (Figure 1), is a floating-leaved/emergent aquatic fern of global distribution, inhabiting the tropical and warm temperate regions of Europe, Asia, and North and South America (Husak and Otahelova 1986). Its main habitats are paddy fields, irrigation ditches, and ponds. It is an amphibious leptosporangiate fern (their sporangia arise from a single epidermal cell and not from a group of cells as in eusporangiate ferns) that is characterized by unusual reproductive structures and heterospory (the production of spores of two different sizes and sexes) (Bruni et al. 2013). Sporocarps possess a unique evolutionary history linked to clonal reproductive strategies which has likely played a critical role in the establishment of this species outside of its native range. EWC is often selected for commercial ornamental use because it can be easily cloned and grown in a greenhouse. Nevertheless, colonization events could occur via animal dispersal. Bruni et al. (2013) reported that sporocarps are eaten by waterfowl and pass through the digestive tract undamaged.

INVASIVENESS OF EWC:

In India, Southern Europe, and Central Asia, EWC has been increasing and is considered a noxious weed, often occupying areas that experience frequent flooding (Husak and Otahelova 1986). A stress-tolerant species, EWC displays an invasive character by forming dense colonies in sluggish water. The Michigan Department of Environmental Quality (DEQ) has reported this species in similar environments (e.g., Barton and Argo Ponds) (Steen 2016). However, in many European countries its population is in decline and considered threatened, as well as extinct (e.g., Northern Poland and Spain) (Bruni et al. 2013). Recent sightings have been reported in the Clinton River Watershed in Southeast Michigan (Steen 2016), likely an unintentional release from ornate use.

NATIVE CHARACTERISTICS AND GROWTH HABIT OF EWC:

In its native range, EWC grows in moderately eutrophic waters of a slightly acid to neutral pH and compact loam-clay soils with sufficient minerals and little organic matter (Husak and Otahelova 1986). Optimal growth occurs at a water level that fluctuates within the limits of +/-0.24 m, although it can tolerate depths > 0.5 m and persist on soil without water (Husak and Otahelova 1986). In addition to water depth, sediment conditions play a key role in controlling the distribution patterns of ECW. Bolpagni and Pino (2017) found that growth peaked in slightly eutrophic waters, while persisting, though inhibited, under elevated nutrient levels. Eutrophication causes an increase in organic matter and mineralization rates which may lead to an accumulation of phytotoxic compounds in sediment top layers along with rapid oxygen depletion, stressing rooted aquatic plants. However, stoloniferous taxa, such as EWC can escape the negative effects of toxic sediments through clonal growth (Bolpagni and Pino 2017). Fluctuating water levels and moderately eutrophic sediments may strongly favor EWC.

To cope with variable environmental conditions encountered in shallow aquatic habitats, EWC has developed heterophyllous submerged, floating, and emergent leaves. When completely submerged, the plant produces four elongated fork-like leaflets and when the leaflets are emergent, they expand, resembling a four-leaf clover (Lin et al. 2007). Lin et al. (2007) suggest carbon gain as one of the driving forces for the development of heterophylly, possibly a morphological acclimation of EWC to aquatic and terrestrial environments. The presence of trichomes on terrestrial leaves is imperative to reducing water loss when leaves become emergent during dry conditions, reflecting light and protecting against the damaging effect of photoinhibition (Wu and Kao 2009). EWC is not only able to adjust leaf characteristics in response to transitions between aquatic and terrestrial environments, but is also able to adjust leaflet angle in response to changes in the position of the sun's direct beam (Kao and Lin 2010). Diurnal phototropic leaf movement, representing a transition from aquatic to terrestrial conditions, maximizes the interception of light to increase carbon gain. Morphological and environmental plasticity contributes to the ability of EWC to occupy a continuum of habitats from terrestrial soils to continuously flooded littoral zones (Garbey et al. 2004).

The colonization of aquatic habitats by heterosporous ferns has led to one of the most sophisticated reproductive systems, comprising of both asexual and sexual reproduction. Sporocarp dispersal maximizes sexual reproductive success by releasing both micro- and megaspores simultaneously (the equivalent of sperm and egg) to stimulate the development of the micro- and megagametophytes (Schneider and Pryer 2002). Upon the release and dispersal of spores, fertilization ensues at the surface, then developing embryos sink and adhere to the substrate, quickly changing from rhizoids to roots (Schneider and Pryer 2002). Asexual reproduction occurs via adventitious lateral roots that arise from nodes on the rhizome (Lin and Raghavan 1991). The formation of lateral roots is an important feature in the ontogeny of parent plants and the ability of EWC to persist and form monocultures over time (Bruni et al. 2013). Additionally, viable sporocarps can remain dormant in the substrate for long periods of time, along with overwintered rhizomes.

EWC IMPAIRMENTS TO INLAND LAKES:

Michigan's freshwater ecosystems have experienced significant ecological damage and economic costs from aquatic invasive species. Currently, a lack of species-specific data for EWC, such as competition and predation, generates much uncertainty regarding the invasiveness of this species. In an Illinois (IL) stream system, Henry (1983) concluded that EWC had not been highly aggressive in its spread or migration, traveling only one mile in 35 years. He found distribution to be widely scattered, usually in sluggish water at stream edges near a lake (Henry 1983). In Arkansas, Simpson et al. (2008) found a single patch in sluggish water where a river broadened. It was inferred that its appearance was a recent introduction by waterfowl. Recent investigations suggest that both cultural (Herbicides and Eutrophication) and environmental (Sediment Dynamics and Water Current) constraints could impose limits on population expansion. According to the Midwest Invasive Species Network, water clover is not listed as an invasive species in IL but is listed as invasive in Michigan, and accordingly on the state's watch list. While presently available for sale and possession in Michigan, the best way to avoid potential adverse impacts, is to identify, monitor, and control newly established populations.

MANAGEMENT OF EWC:

Lake Angelus is a 477-acre mesotrophic lake located in Oakland County, Michigan. EWC was first found along the shoreline of a lagoon on the lake in 2015 (Figure 2) and had been treated with aquatic herbicides such as diquat and flumioxazin. The diquat resulted in better control of EWC and sustained a reduced population through an entire season. Other natural methods of control should also be pursued as management options. As described above, the plant should be managed to reduce the threat to other native shoreline aquatic plant species that are necessary for a biodiverse aquatic ecosystem.

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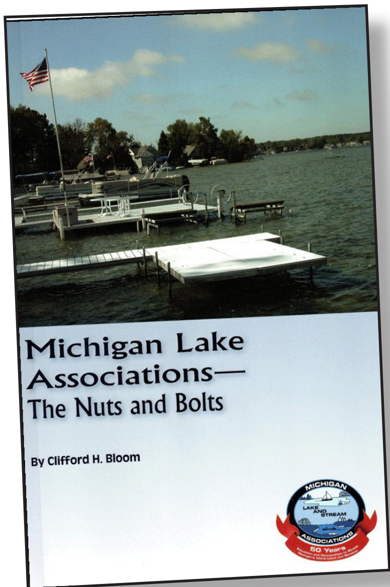

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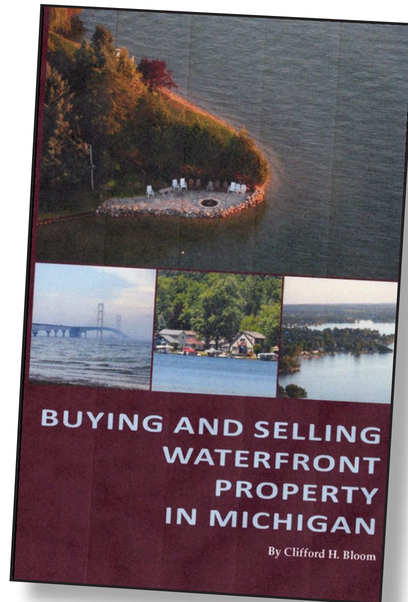

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References:

Bolpagni, R., and F. Pino. 2017. Sediment nutrient drivers of the growth dynamics of the rare fern Marsilea quadrifolia. Hydrobiologia 792:303-314.

Bruni, I., R. Gentili, F. De Mattia, P. Cortis, G. Rossi, and M. Labra. 2013. A multi-level analysis to evaluate the extinction risk of and conservation strategy for the aquatic fern Marsilea quadrifolia L. in Europe. Aquatic Botany 111:35-42.

Garbey, C., G. Thiebaut, and S. Muller. 2004. Morphological plasticity of a spreading aquatic macrophyte, Ranunculus peltatus, in response to environmental variables. Plant Ecology 173:125-137.

Henry, R. D. 1983. Spread of Marsilea quadrifolia in McDonough County, Illinois. American Fern Journal 73:30-30.

Husak, S., and H. Otahelova. 1986. Contribution to the Ecology of Marsilea-quadrifolia L. Folia Geobotanica & Phytotaxonomica 21:85-&.

Kao, W. Y., and B. L. Lin. 2010. Phototropic leaf movements and photosynthetic performance in an amphibious fern, Marsilea quadrifolia. Journal of Plant Research 123:645-653.

Lin, B. L., and V. Raghavan. 1991. Lateral root initiation in Marsilea-quadrifolia. 1. Origin and histogenesis of lateral roots. Canadian Journal of Botany-Revue Canadienne De Botanique 69:123-135.

Lin, C.-H., B.-L. Lin, and W.-Y. Kao. 2007. Leaf Characteristics and Photosynthetic Performance of Floating, Emergent and Terrestrial Leaves of Marsilea quadrifolia. Taiwania 52:195-200.

Schneider, H., and K. M. Pryer. 2002. Structure and function of spores in the aquatic heterosporous fern family Marsileaceae. International Journal of Plant Sciences 163:485-505.

Simpson, J., D. Crank, and J. H. Peck. 2008. Two exotic ferns, Dryopteris erythrosora and Marsilea quadrifolia, newly naturalized in Arkansas. American Fern Journal 98:111-112.

Steen, P. 2016. Searching for European Water Clover. Huron River Watershed Council. Huron River Report.

Wu, T. C., and W. Y. Kao. 2009. The Function of Trichomes of an Amphibious Fern, Marsilea quadrifolia. American Fern Journal 99:323-332.