

Preferences	Sandy, loamy, or peaty soils; acid, neutral, and basic (alkaline) soils; moist to wet soils ⁸ ; semi- or no shade
c. Regulation	
Noxious/Regulated ² :	CT
Minnesota Regulations:	<i>Not regulated</i>
Michigan Regulations:	<i>Not regulated</i>
Washington Regulations:	<i>Not regulated</i>
II. Establishment Potential and Life History Traits	
a. Life History	Floating leaved aquatic to amphibious rhizomatous fern ³
Fecundity	High
Reproduction	Asexual (forms clones) ⁵ ; Sexual ³
Importance of Spores:	Sporocarps lie dormant for decades; male and female spores cross-fertilize in wet conditions ³
Vegetative:	Mainly reproduces clonally ³
Hybridization	Three hybrids are generally recognized among New World <i>Marsilea</i> ⁴
Overwintering	
Winter Tolerance:	High
Phenology:	Forms overwintering underground rhizomes ³
b. Establishment	
Climate	
Weather:	Temperate regions; hardy to -15°C ⁽⁸⁾
Wisconsin-Adapted:	Very likely
Climate Change:	Increased flooding could lead to increases in and spread of <i>M. quadrifolia</i> populations ⁹
Taxonomic Similarity	
Wisconsin Natives:	Low
Other US Exotics:	High; <i>M. minuta</i> and <i>M. hirsuta</i> in southern United States ² (both pose greater threats than <i>M. quadrifolia</i>); <i>M. mutica</i> ^{3, 10}
Competition	
Natural Predators:	Waterfowl consume the sporocarps ¹¹
Natural Pathogens:	Undocumented
Competitive Strategy:	Extreme environmental plasticity ⁴
Known Interactions:	Undocumented
Reproduction	
Rate of Spread:	High
Adaptive Strategies:	Long propagule dormancies; self-compatibility; early successional habitats ⁴
Timeframe	Undocumented
c. Dispersal	
Intentional:	Ornamental ^{5,6}
Unintentional:	Sporocarps, waterbirds, flowing water ⁴ ; escape from cultivation ⁶
Propagule Pressure:	High; long propagule dormancies ⁴ , source populations near Wisconsin



Figures 2 and 3: Courtesy of Eleanor Saulys; Connecticut Botanical Society¹²

III. Damage Potential

a. Ecosystem Impacts

Composition	May affect local mollusk communities ¹³ ; may crowd out native wetland plants ¹⁴
Structure	Occurrence in early successional habitats ⁴
Function	Undocumented
Allelopathic Effects	Undocumented
Keystone Species	Undocumented
Ecosystem Engineer	Undocumented
Sustainability	Undocumented
Biodiversity	Undocumented
Biotic Effects	Undocumented
Abiotic Effects	Undocumented
Benefits	Undocumented

b. Socio-Economic Effects

Benefits	Some edible and medicinal uses ⁸
Caveats	Imported plant parts (such as sporocarps), could lead to accidental introduction; risk of release and population expansion outweighs benefits of use
Impacts of Restriction	Increase in monitoring, education, and research costs
Negatives	Undocumented
Expectations	More negative impacts can be expected in low energy, shallow systems
Cost of Impacts	Decreased recreational and aesthetic value; decline in ecological integrity; increased research expenses
“Eradication” Cost	Expensive

IV. Control and Prevention

a. Detection

Crypsis:	Low
Benefits of Early Response:	Undocumented

b. Control	
Management Goal 1	Nuisance relief
Tool:	Chemical (butachlor) ⁹
Caveat:	<i>M. quadrifolia</i> is tolerant to most of the grass killer herbicides ⁹ ; negative impacts on non-target species
Cost:	Undocumented
Efficacy, Time Frame:	Low
Tool:	Chemical (bensulfuron-methyl; simetryn) ¹⁵
Caveat:	May have adverse effects on other non-target species
Cost:	Undocumented
Efficacy, Time Frame:	Efficient in controlling <i>M. quadrifolia</i> ; leaves and rhizomes most inhibited by bensulfuron-methyl, while root growth most inhibited by simetryn ¹⁵

¹ US Forest Service, Pacific Island Ecosystems at Risk (PIER). 2007. *Marsilea quadrifolia* L., Marsileaceae. Retrieved December 28, 2010 from:

http://www.hear.org/pier/species/marsilea_quadrifolia.htm

² United States Department of Agriculture, Natural Resource Conservation Service. 2010. The PLANTS Database. National Plant Data Center, Baton Rouge, LA, USA. Retrieved December 28, 2010 from: <http://plants.usda.gov/java/profile?symbol=MAQU>

³ United States Geologic Survey, Nonindigenous Species. 2010. Retrieved December 28, 2010 from: http://cars.er.usgs.gov/Region_5_Report/html/emergent_plants.html

⁴ Johnson, D.M. 1986. Systematics of the New World species of *Marsilea* (Marsileaceae). Systematic Botany Monographs 11:1-87.

⁵ Flora of North America. *Marsilea quadrifolia* Linnaeus. Retrieved December 28, 2010 from: http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=200005211

⁶ Les, D.H. and L.J. Mehrhoff. 1999. Introduction of nonindigenous aquatic vascular plants in southern New England: a historical perspective. Biological Invasions 1:281-300.

⁷ The Planted Tank. Four Leaf Clover (*Marsilea quadrifolia*). Retrieved November 23, 2010 from: http://www.plantedtank.net/forums/myplants/86-Four_Leaf_Clover_Water_Shamrock_Marsilea_quadrifolia.html

⁸ Plants for a Future Database. 2010. *Marsilea quadrifolia* L., Water Clover. Retrieved December 28, 2010 from: <http://www.pfaf.org/user/Plant.aspx?LatinName=Marsilea%20quadrifolia>

⁹ Kathiresan, R.M. 2006. Effects of Global Warming on Invasion of Alien Plants in Asia. Annamalai University, India (Symposium).

¹⁰ Jacono, C.C. 2002. United States Geological Survey - Nonindigenous Aquatic Species. Nonindigenous *Marsilea*, water-clover, aquatic fern. Retrieved December 28, 2010 from: <http://nas.er.usgs.gov/taxgroup/plants/docs/marsilea/marsilea.html>

¹¹ Martin, A.C. and F.M. Uhler. 1939. Food of game ducks in the United States and Canada. US Department of Agriculture Technical Bulletin No 634, GPO, Washington, DC, 157 pp.

¹² Saulys, E. 2002. Connecticut Botanical Society. Retrieved December 28, 2010 from: <http://www.ct-botanical-society.org/ferns/marsileaquad.html>

¹³ United States Environmental Protection Agency. 2008. Predicting future introductions of nonindigenous species to the Great Lakes. National Center for Environmental Assessment,

Washington, DC; EPA/600/R-08/066F. Retrieved November 23, 2010 from:
<http://cfpub1.epa.gov/ncea/cfm/recordisplay.cfm?deid=190305>

¹⁴ Cao, L. 2008. *Marsilea quadrifolia*. United States Geological Survey Nonindigenous Aquatic Species Database, Gainesville, FL. Retrieved December 28, 2010 from:
<http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=293>

¹⁵ Luo, X-Y. and H. Ikeda. 2007. Effects of four rice herbicides on the growth of an aquatic fern, *Marsilea quadrifolia* L. *Weed Biology and Management* 7(4):237-241.