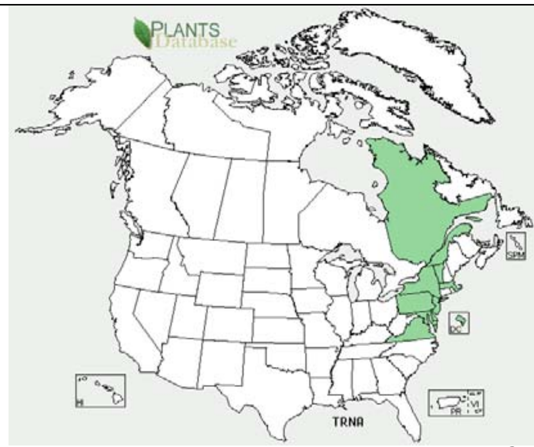
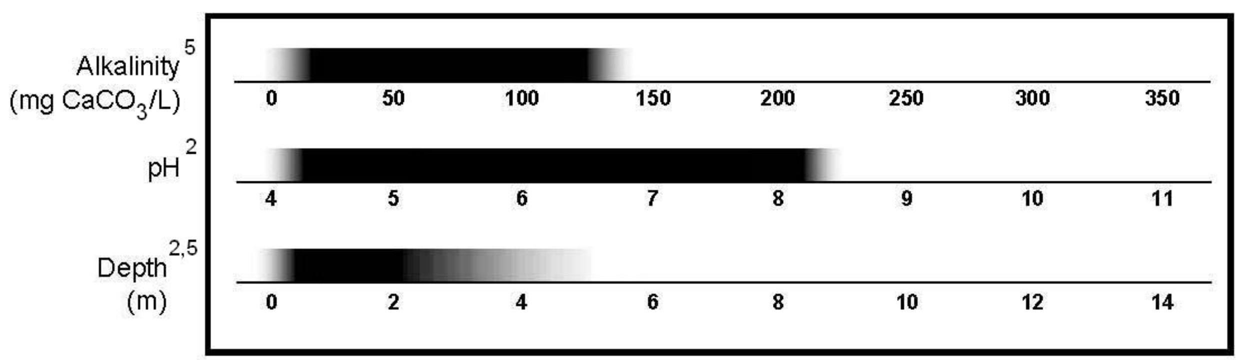
Aquatic Plant		Water Chestnut
I. Current Status and Distribution		***Trapa natans***
a. Range	**Global/Continental**	**Wisconsin**
Native Range Eurasia and Africa[1,3]	 *Figure 1: U.S and Canada Distribution Map*[2]	Not recorded in Wisconsin
Abundance/Range		
Widespread:	Southern New Hampshire, Maryland, Massachusetts, western Vermont, eastern New York, northern Virginia[3]	Not applicable
Locally Abundant:	Eutrophic low-energy systems[3]	Not applicable
Sparse:	High-energy oligotrophic systems; rare in Europe and Russia[3]	Not applicable
Range Expansion		
Date Introduced:	Massachusetts, 1874[3]	Not applicable
Rate of Spread:	Extremely rapid; 10 fold increase in one year on Lake Champlain[4]	Not applicable
Density		
Risk of Monoculture:	High; considered nuisance even within native range; dry weight of 100-1500 g/m^2 (3)	Unknown
Facilitated By:	Sheltered, high fertility systems[3]	Unknown
b. Habitat	Lakes, reservoirs, wetlands, ponds, rivers, streams, estuaries, low energy systems[3]	
Tolerance	Chart of tolerances: Increasingly dark color indicates increasingly optimal range	



Preferences	Full sun, slow-moving, nutrient-rich fresh waters and soft substrate[3]; density is positively related to soluble nitrate levels[3]

c. Regulation	
Noxious/Regulated[2,3]:	AL, AZ, CT, FL, MA, ME, NC, NH, OR, SC, VT, WA
Minnesota Regulations:	*Prohibited*; One may not possess, import, purchase, propagate, or transport
Michigan Regulations:	*Prohibited*; One may not knowingly possess or introduce
Washington Regulations:	*Priority Species of Concern*; State Wetland and Aquatic or Noxious Weed Quarantine List
II. Establishment Potential and Life History Traits	
a. Life History	Annual floating-leaf[3], but can outcompete perennials[4]
Fecundity	High
Reproduction Importance of Seeds: Vegetative:	Sexual (pollinated in air, vector unknown); Asexual (self-pollinating)[3] High; up to 10 year dormancy[3] Clonal growth: genets and ramets (up to 27 per plant) disperse and produce more seeds[4]
Hybridization	Undocumented
Overwintering Winter Tolerance: Phenology:	 High; seeds can overwinter in sediments for up to 10 years[3] Emerges as rosettes in May; present on water surface from June to September; dies back and decomposes in autumn[3]
b. Establishment	
Climate Weather: Wisconsin-Adapted: Climate Change:	 Temperate and tropical[3] Likely Flooding may increase dispersal
Taxonomic Similarity Wisconsin Natives: Other US Exotics:	 Medium; when placed in Lythraceae[3] Medium; when placed in Lythraceae[3]
Competition Natural Predators: Natural Pathogens: Competitive Strategy: Known Interactions:	 *Ondatra* zibethicus (muskrat), *Castor canadensis* (beaver), and various rodents[3]; *Odocoileus* virginianus (white tail deer)[3]; *Galerucella* spp. (native water-lily leaf beetle)[3] *Sclerotium hydrophilum* Sacc. (fungus) and *Bipolaris tetramera*[3]; must be artificially increased for biocontrol Clonal growth; shading other plants; long-lived seeds Replaced *Vallisneria americana*, *Potamogeton perfoliatus*, and exotic *Myriophyllum spicatum* in the Hudson River[3]
Reproduction Rate of Spread: Adaptive Strategies:	 High Clonal growth; ramets and genets increase seed set[4]
Timeframe	10 fold increase in one year; from low level to monoculture in five years[4]; addressing nutrient input can lessen risk of monoculture[3]
c. Dispersal	
Intentional: Unintentional: Propagule Pressure:	Ornamental, aquarium trade, cultivation[3] Water and wind currents, animals (waterfowl/mammals), humans (clothing), boats, construction equipment, vehicles[3] Medium; fragments relatively easily accidentally introduced

Figure 2: Courtesy of Leslie J. Mehrhoff, University of Connecticut, Bugwood.org [6]
Figure 3: Courtesy of John M. Randall, The Nature Conservancy, Bugwood.org [7]

III. Damage Potential

a. Ecosystem Impacts	
Composition	Displaces submerged aquatic plants[3]; shades out microscopic flora and fauna[3]; epiphyton significantly lower in *T. natans* beds versus submersed plant beds[3]; destructive to duck-food beds[3]; fish kills as result of dissolved oxygen depletion[8]; facilitates growth of algae and duckweed[3]
Structure	Monocultures; alters community architecture[3]; fish respond to changes in architecture and dissolved oxygen levels[3]
Function	Decrease in dissolved oxygen concentration[9,10]; dense mats decrease light penetration by 95%; increase in dissolved organic carbon[3]; decreased water flow
Allelopathic Effects	Undocumented
Keystone Species	Undocumented
Ecosystem Engineer	Yes; dense canopy decreases light penetration
Sustainability	Undocumented
Biodiversity	Decreases under dense cover, may increase when at non-nuisance levels[3]
Biotic Effects	Impacts native species at multiple trophic levels
Abiotic Effects	Reduced dissolved oxygen concentration and light penetration[3]
Benefits	Provides habitat for invertebrates and fish when at non-nuisance levels[3]

b. Socio-Economic Effects	
Benefits Caveats	Nitrogen removal[3]; agricultural product[3]; medicinal and nutritional uses[3,11]; habitat and food for wildlife[3] Risk of release and population expansion outweigh benefits of use
Impacts of Restriction	Increase in monitoring, education, and research costs
Negatives	Navigating and recreating becomes difficult or impossible[3]; breeding habitat for mosquitoes[3]; dense beds implicated in three drownings[3]; raw nuts are vector of the giant intestinal fluke that causes fasciolopsiasis[3]; associated increase in dissolved organic carbon could be precursor to contaminated drinking water[3]; barbed spine tips on nuts cause injury, can also break off in the skin and cause infection[3]
Expectations	More negative impacts can be expected in sheltered, eutrophic systems[3]
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; *Trapa bicornis* also regulated in several states, though not known to occur in the United States[2]
Benefits of Early Response:	Medium to high[5]: early response limits seed bank; seeds are slow to be produced but are viable for up to 10 years[3]
b. Control	
Management Goal 1	Nuisance relief
Tool:	Hand-pulling; high speed cutting[3]
Caveat:	Must remove rosettes before fruits mature[3]
Cost:	Expensive; 20 years of effort cost several hundred thousand dollars in the Potomac River[3]
Efficacy, Time Frame:	Oftentimes must be coupled with chemical controls[3]
Tool:	2,4-D in high concentration[3]
Caveat:	Non-target plant species are negatively impacted
Cost:	Expensive
Efficacy, Time Frame:	Combine with mechanical control; must commit to at least 10-12 years of effort
Management Goal 2	Biological control
Tool:	Triploid grass carp
Caveat:	Non selective grazers; stocking is illegal due to occasional fertility
Cost:	Undocumented
Efficacy, Time Frame:	Repeated stocking of 300-400 carp per 1 to 1.5ha effective[3]
Tool:	*Galerucella* spp.[3,8]
Caveat:	Non-target plant species are negatively impacted
Cost:	Undocumented
Efficacy, Time Frame:	Natural populations must be augmented
Tool:	*Sclerotium hydrophilum* and *Bipolaris tetramera* (fungi)[3]
Caveat:	Scarce literature available on non-target or long-term impacts
Cost:	Undocumented
Efficacy, Time Frame	Must be artificially increased for biocontrol
Documented Cost	$5.3 million spent on Lake Champlain since 1982[12]

[1] United States Department of Agriculture, National Agricultural Library, National Invasive Species Information Center. Water Chestnut (*Trapa natans*). Retrieved December 22, 2010 from: http://www.invasivespeciesinfo.gov/aquatics/waterchestnut.shtml

[2] United States Department of Agriculture, Natural Resource Conservation Service. 2010. The PLANTS Database. National Plant Data Center, Baton Rouge, LA, USA. Retrieved December 22, 2010 from: http://plants.usda.gov/java/profile?symbol=TRNA

[3] Hummel, M. and E. Kiviat. 2004. Review of world literature on water chestnut with implications for management in North America. Journal of Aquatic Plant Management 42:17-28.

[4] Groth, A.T., L. Lovett-Doust and J. Lovett-Doust. 1996. Population density and module demography in *Trapa natans* (Trapaceae), an annual, clonal aquatic macrophyte. American Journal of Botany 83(11):1406-1415.

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[6] Mehrhoff, L.J. University of Connecticut. Retrieved December 22, 2010 from: http://www.bugwood.org

[7] Randall, J. The Nature Conservancy. Retrieved December 22, 2010 from: http://www.bugwood.org

[8] Ding, J., B. Blossey, Y. Du and F. Zheng. 2006. *Galerucella birmanica* (Coleoptera: Chrysomelidae), a promising potential biological control agent of water chestnut, *Trapa natans*. Biological Control 36(1):80-90.

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[10] Tsuchiya, T. and T. Iwakuma. 1993. Growth and leaf life-span of a floating-leaved plant, *Trapa natans* L., as influenced by nitrogen influx. Aquatic Botany 46:317-324.

[11] Hijikata, Y., A. Yasuhara and Y. Sahashi. 2005. Effect of an herbal formula containing *Ganoderma lucidum* on reduction of herpes zoster pain: a pilot clinical trial. American Journal of Chinese Medicine 33(4):517-523.

[12] Wu, J. and M. Wu. 2006. Feasibility study of effect of ultrasound on water chestnuts. Ultrasound in Medicine and Biology 32(4):595-601.