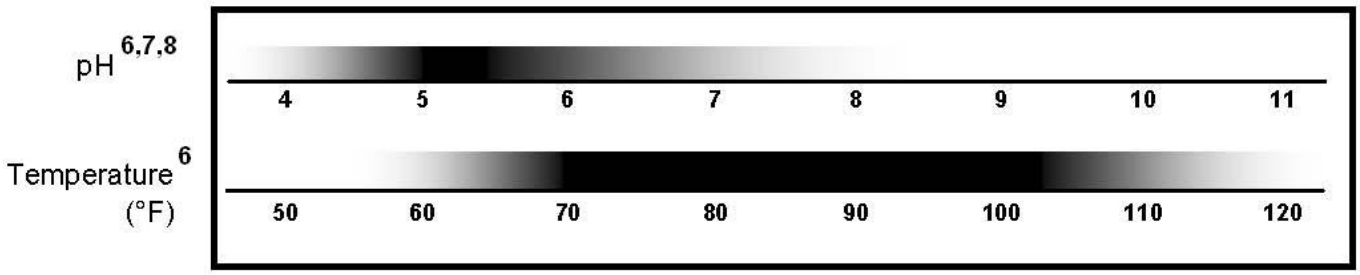
Aquatic Plant	Feathered Waterfern; Ferny Azolla; Water Velvet; Mosquito Fern

I. Current Status and Distribution		***Azolla pinnata***
a. Range	**Global/Continental**	**Wisconsin**
Native Range Africa, Madagascar, India, China, Southeast Asia, Japan, Malaysia, Philippines, Vietnam, New Guinea, Australia[1,19]	 *Figure 1: U.S and Canada Distribution Map*[2]	Not recorded in Wisconsin[3]
Abundance/Range Widespread: Locally Abundant: Sparse:	 New Zealand and Southeast Asia Unknown Not widespread in the U.S.; found in a North Carolina water garden store[4]	 Not applicable Not applicable Not applicable
Range Expansion Date Introduced: Rate of Spread:	 North Carolina, 1999[4] Not known to be spreading in the U.S.; capable of doubling population in 3-5 days[5]	 Not applicable Not applicable
Density Risk of Monoculture: Facilitated By:	 High; can completely cover the water surface[1,6] High water temperature, acidic water, high nutrient levels[1,6]	 Unknown Unknown
b. Habitat	Ponds, backwaters, lakes, reservoirs, wetlands, rivers, ditches, rice paddy fields, moist soil, and low energy systems[1,4]	
Tolerance	Chart of tolerances: increasingly dark color indicates increasingly optimal range	



Preferences	Acidic conditions, relative humidity greater than 60%, high water temperatures, high phosphorus[6,9]

c. Regulation	
Noxious/Regulated[2,19]:	Federal Noxious Weed List; AL, CA, MA, NC, OK, OR, SC, VT
Minnesota Regulations:	*Prohibited*; One may not possess, import, purchase, propagate, or transport
Michigan Regulations:	*Not regulated*
Washington Regulations:	*Not regulated*
II. Establishment Potential and Life History Traits	
a. Life History	Free-floating, perennial fern
Fecundity	High
Reproduction Importance of Spores: Vegetative:	Sexual; Asexual Produces sporocarps Probably most important
Hybridization	Undocumented
Overwintering Winter Tolerance: Phenology:	 Undocumented In Asia, maximum growth from September to January, and decline during April to June[6]; prolific up to March in India[6]
b. Establishment	
Climate Weather: Wisconsin-Adapted: Climate Change:	 Highest laboratory productivity at relative humidity between 85-95%; can survive temperatures between 14-40°C (57-104°F)[6] Uncertain Likely to facilitate growth and distribution
Taxonomic Similarity Wisconsin Natives: Other US Exotics:	 High; *Azolla caroliniana*, *Azolla mexicana*[2,4] Low
Competition Natural Predators: Natural Pathogens: Competitive Strategy: Known Interactions:	 Undocumented Undocumented Symbiosis with nitrogen-fixing cyanobacteria[6,10]; rapid reproduction; shades sub-surface vegetation[5,10,11] *Vallisneria americana* decreases due to shading[11]; replaced native *A. rubra* in northern New Zealand[10]; symbiotic association with *Anabaena azollae* (blue green algae)[6]
Reproduction Rate of Spread: Adaptive Strategies:	 High Auto-fragmentation; can survive drawdown and drought[4,10]
Timeframe	Capable of doubling population in 3-5 days[5]
c. Dispersal	
Intentional: Unintentional: Propagule Pressure:	Aquarium trade; agricultural fertilizer[10]; nutrient[12] and heavy metal effluent treatment[13,14] Wind, water, humans; transport of cattle[10] Low; fragments easily accidentally introduced, but source populations not near Wisconsin

Figures 2 and 3: Courtesy of Sheldon Navie[15]

III. Damage Potential	
a. Ecosystem Impacts	
Composition	Native plant richness and abundance decreases[11]; macroinvertebrate density (zooplankton) and phytoplankton decreases significantly[16]; fish production decreases[16]
Structure	Monocultures[11]; changes community architecture[11]
Function	Decreases dissolved oxygen concentration and light penetration[11]
Allelopathic Effects	Undocumented
Keystone Species	Undocumented
Ecosystem Engineer	Yes; dense surface growth decreases dissolved oxygen concentration and light penetration[11]
Sustainability	Undocumented
Biodiversity	Decreases
Biotic Effects	Reduces submerged plants; decreases fish productivity
Abiotic Effects	Decreases dissolved oxygen concentration and light penetration[11]; decreases pH, conductivity, and nutrient concentrations[16]; degrades water quality[4]; symbiotic cyanobacteria fix nitrogen[5]
Benefits	Undocumented
b. Socio-Economic Effects	
Benefits Caveats	Agricultural green fertilizer[1,5,10]; nutrient[6,12,16] and heavy metal effluent treatment[13,14]; poultry and duck feed[6]; antifungal agent[6]; source of hydrogen gas[6]; mosquito-controlling agent[6] Risk of release and population expansion outweighs benefits of use
Impacts of Restriction	Increase in monitoring, education, and research costs
Negatives	Dense surface growth is unsightly and inhibits recreation[4,10]; clogs irrigation pumps and impedes water flow[15]; likely to decrease native diversity and abundance; dense growth of a similar species (*A. filiculoides*) has led to drowning of livestock[17]
Expectations	More negative impacts can be expected in warm, low-energy systems
Cost of Impacts	Decreased recreational and aesthetic value; decline in ecological integrity; increased research expenses
"Eradication" Cost	Undocumented

IV. Control and Prevention	
a. Detection	
Crypsis:	High; confused with natives *A. caroliniana*, *A. mexicana*
Benefits of Early Response:	High; early response may limit vegetative reproduction and spread between waterbodies
b. Control	
Management Goal 1	Nuisance relief
Tool:	Manual/mechanical harvest
Caveat:	Rapid re-growth means relief is very short-lived; negative impacts on non-target species
Cost:	Estimated $1000/ha/year (on similar species)[17]
Efficacy, Time Frame:	Control must occur several times per year
Tool:	Small-scale chemical
Caveat:	Rapid re-growth means relief is very short-lived; negative impacts on non-target species
Cost:	Estimated $136/ha/year (on similar species)[17]
Efficacy, Time Frame:	Control must occur several times per year
Tool:	Biological control (*Stenopelmus rufinasus*, water fern weevil)
Caveat:	Might be suitable, but *A. pinnata* is not a preferred host[18]
Cost:	Initial $7700 investment, plus an estimated $276/ha/year (on similar species)[17]
Efficacy, Time Frame:	Depends on host specificity (not researched thoroughly for *A. pinnata*)

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