Weed Risk Assessment for *Nymphoides peltata* (S. G. Gmel.) Kuntze (Menyanthaceae) – Yellow floating heart

United States Department of Agriculture

Animal and Plant Health Inspection Service

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Version 1

Nymphoides peltata plants in flower (source: Falling Water Designs, 2009).

Agency Contact:

Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health Science and Technology

Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

Introduction Plant Protection and Quarantine (PPQ) regulates noxious weeds under the authority of the Plant Protection Act (7 U.S.C. § 7701-7786, 2000) and the Federal Seed Act (7 U.S.C. § 1581-1610, 1939). A noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (7 U.S.C. § 7701-7786, 2000). We use weed risk assessment (WRA) - specifically, the PPQ WRA model (Koop et al., 2012) - to evaluate the risk potential of plants, including those newly detected in the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States or for any area within it. As part of this analysis, we use a stochastic simulation to evaluate how much the uncertainty associated with the analysis affects the model outcomes. We also use GIS overlays to evaluate those areas of the United States that may be suitable for the establishment of the plant. For more information on the PPQ WRA process, please refer to the document, *Background information on the PPQ Weed Risk Assessment*, which is available upon request.

Nymphoides peltata (Gmel.) O. Kuntze - Yellow floating heart

Species Information

Family: Menyanthaceae

Initiation: On October 28, 2010, Rick Iverson, weed specialist with the North Carolina Department of Agriculture and Consumer Services, notified Al Tasker (Plant Protection and Quarantine) of his intent to regulate three species of *Nymphoides* as state Noxious Weeds in North Carolina. Mr. Iverson asked if PPQ had done weed risk assessments for these species. The Plant Epidemiology and Risk Analysis Laboratory, which had already completed one of the assessments (*N. cristata*), decided to collaborate with Mr. Iverson to complete the other two: *N. peltata* (this WRA) and *N. indica* (Iverson, 2010).

Foreign distribution: This species is native to temperate Asia and Europe (NGRP, 2012). It is present as a non-native species in Canada, New Zealand, and Ireland (CABI, 2012; NGRP, 2012; Nault and Mikulyuk, 2009).

U.S. distribution and status: *Nymphoides peltata* is sold in the United States as a water garden plant at wholesale and retail distributors (Dave's Garden, 2012; University of Minnesota, 2008). It has been in the North American plant trade since at least 1930 (Bailey, 1930). *Nymphoides peltata* is naturalized in 25 U.S. states [AR, AZ, CA, DC, DE, IL, IN, KY, LA, MA, MD, MO, MS, NE, NH, NJ, NY, OH, OK, PA, RI, TN, TX,

VT, and WA (Kartesz, 2012)] and is regulated in Connecticut, Maine, Massachusetts, North Carolina, Oregon, Vermont, and Washington (NRCS, 2012). Control efforts include biomass removal and herbicide application (DCR, 2011).

WRA area: Entire United States, including territories

1. *Nymphoides peltata* analysis

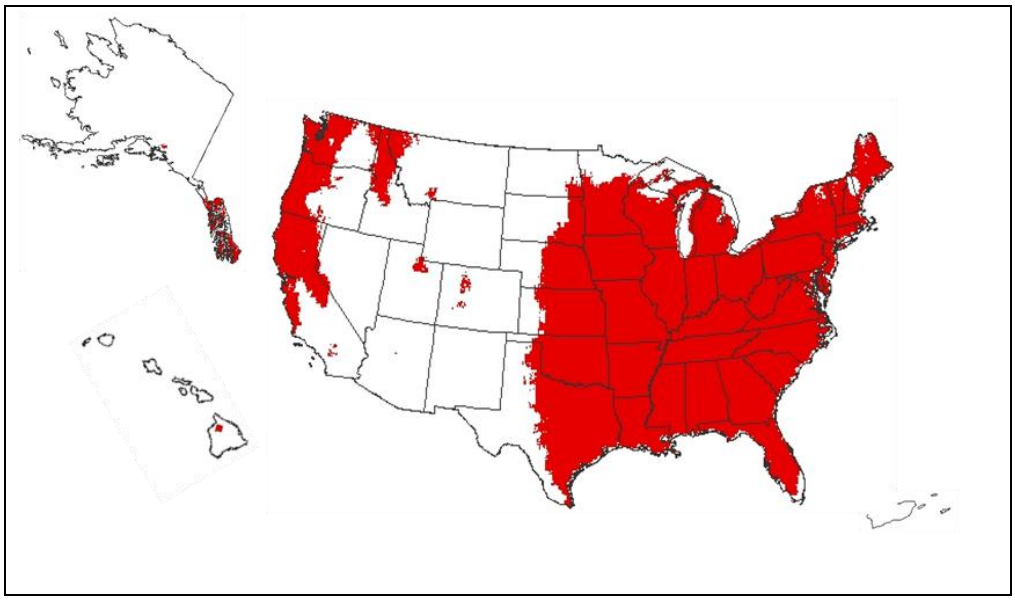
Establishment/Spread Potential *Nymphoides peltata* is an aggressive, emergent aquatic plant that develops dense mats on the surface of water bodies (ISSG, 2012). Vegetative fragments of *Nymphoides peltata* are capable of colonizing an entire water body within a few years (Kelly and Maguire, 2009). The seed surfaces have trichomes that help the seeds attach to water fowl (Cook, 1990; Countryman, 1970; Smits et al., 1989) and float in the water (Countryman, 1970; Smits et al., 1989). When grown in outdoor water gardens, *N. peltata* can spread unintentionally to new areas during heavy rains (UF IFAS, 2011). This element had an average amount of uncertainty associated with it.
Risk score = 18 Uncertainty index = 0.11

Impact Potential Dense mats of *N. peltata* restrict light availability to photosynthetic species underneath, which can exclude native plants (van der Velde, 1976; Kelly and Maguire, 2009). Decay of the senescing vegetation decreases the oxygen levels in water bodies, causing stagnant areas and affecting fish farming (Cazacu and Gache, 2005). This species also limits recreational activities such as swimming, boating, and fishing (Kelly and Maguire, 2009). This element had an average amount of uncertainty associated with it.
Risk score = 4.1 Uncertainty index = 0.16

Geographic Potential Unlike other members of *Nymphoides*, *N. peltata* is able to grow in temperate regions (Nault and Mikulyuk, 2009). We estimate that about 47 percent of the United States is suitable for the establishment of *N. peltata* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *N. peltata* represents the joint distribution of Plant Hardiness Zones 4-11, areas with 20-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: steppe, mediterranean, humid subtropical, humid continental warm summers, humid continental cool summers, and marine west coast (GBIF, 2012; Ricketts et al., 1999). The estimated area likely represents a conservative estimate. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish.

Entry Potential Because the species occurs in the United States (Kartesz, 2012), we did not evaluate this risk element.

Figure 1. Predicted distribution of *Nymphoides peltata* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 92.9%
P(Minor Invader) = 6.9%
P(Non-Invader) = 0.2%

Risk Result = High Risk

Secondary Screening = Not Applicable

Figure 2. *Nymphoides peltata* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

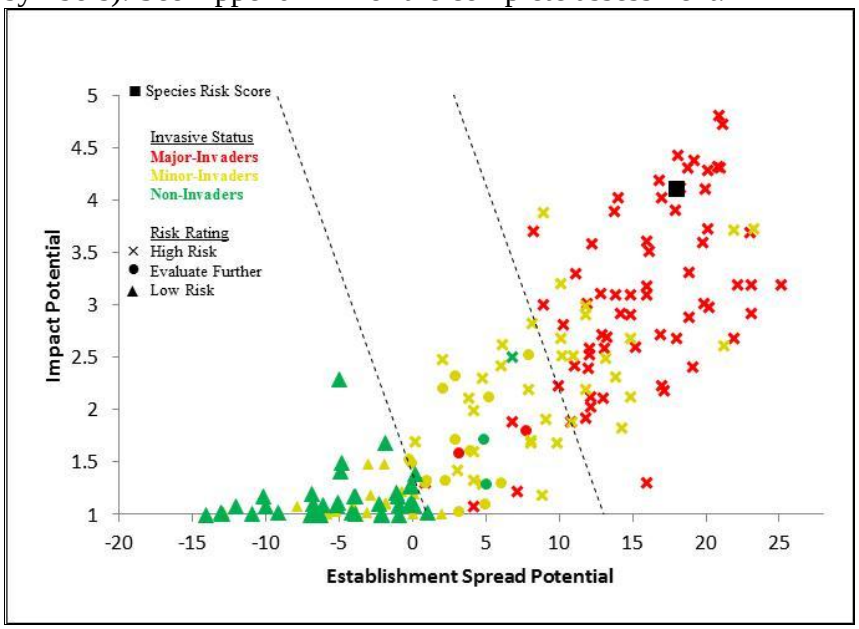
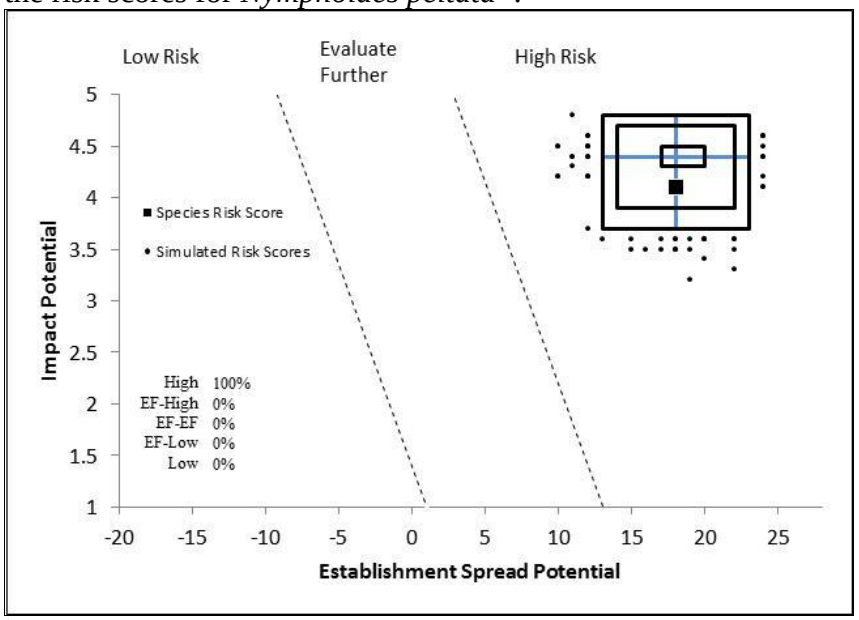


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Nymphoides peltata* [a].



[a] The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *N. peltata* is High Risk. Compared with other species from the WRA validation dataset, *N. peltata* ranked high for both impact and establishment/spread potential (Fig. 2). Our conclusion of High Risk is very robust to uncertainty (Fig. 3). *Nymphoides peltata* mainly threatens natural systems, where it reduces biodiversity, changes community structure, and reduces oxygen levels in the water. *Nymphoides peltata* spreads rapidly to form dense monospecific mats on the surface of aquatic bodies (DCR, 2011), and is regulated by several U.S. states (NRCS, 2012). Regulatory agencies and natural resource managers should consider the extent to which this species is cultivated in their jurisdiction when developing regulatory and management strategies.

4. Literature Cited

7 U.S.C. § 1581-1610. 1939. The Federal Seed Act, Title 7 United States Code § 1581-1610.

7 U.S.C. § 7701-7786. 2000. Plant Protection Act, Title 7 United States Code § 7701-7786.

Bjornerud, B. 2010. Minister's Order: Designation of prohibited, noxious and nuisance weeds in accordance with The Weed Control Act. Minister of Agriculture of Saskatchewan, Regina.

Burrows, G. E., and R. J. Tyrl. 2001. Toxic Plants of North America (First). Iowa State University Press, Ames.

CABI. 2012. Crop Protection Compendium. CAB International. http://www.cabicompendium.org/cpc/home.asp. (Archived at PERAL).

Cazacu, M., and C. Gache. 2005. Comparative observation on the hatching populations of *Chlidonias* genus in the inferior area of the Prut River. Biologie Animala 51:217-220.

CEH. 2004. Information Sheet 6: Fringed waterlily. Center for Ecology and Hydrology (CEH), Natural Environmental Research Council, Center for Aquatic Plant Management. http://www.ceh.ac.uk/sci_programmes/documents/FringedWaterlily.pdf. (Archived at PERAL).

Cook, C. D. K. 1990. Seed dispersal of *Nymphoides peltata* (S.G. Gmelin) O. Kuntze (Menyanthaceae). Aquatic Botany 37:325-340.

Countryman, W. D. 1970. The history, spread and present distribution of some immigrant aquaticweeds in New England. Hyacinth Control Journal 8(2):50-51.

Dave's Garden. 2012. Dave's Garden. http://davesgarden.com/guides/pf/search.php?q=. (Archived at PERAL).

DCR. 2011. Yellow Floating Heart: An exotic aquatic plant, *Nymphoides peltata*. Commonwealth of Massachusetts Department of Conservation and Recreation (DCR), Office of Water Resources, Lakes and Ponds Program.

http://www.mass.gov/dcr/watersupply/lakepond/factsheet/Yellow%20Floating%20Heart.pdf. (Archived at PERAL).

eFlora. 2009. wwweFlora.org. Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA. http://www.efloras.org/. (Archived at PERAL).

Falling Water Designs. 2009. Falling Water Newsletter - August 2009. Last accessed March 2, 2012, http://www.fallingwaterdesigns.com/html/newsletter/aug09/index3.html.

GBIF. 2012. GBIF, Online Database. Global Biodiversity Information Facility (GBIF). gbif.org. http://data.gbif.org/welcome.htm. (Archived at PERAL).

Heap, I. 2011. International survey of herbicide resistant weeds. Weed Science Society of America. www.weedscience.com. http://www.weedscience.org/In.asp. (Archived at PERAL).

Heide-Jorgensen, H. S. 2008. Parasitic Flowering Plants. Brill, Boston. 421 pp.

Holm, L. G., J. V. Pancho, J. P. Herberger, and D. L. Plucknett. 1979. A Geographical Atlas of World Weeds. Krieger Publishing Company, Malabar, Florida, U.S.A. 391 pp.

ISSG. 2012. Global Invasive Species Database. Invasive Species Specialist Group (ISSG), The World Conservation Union (IUCN). Last accessed January 16, 2012, http://www.issg.org/database/welcome/.

Iverson, R. 2010. Risk assessments (RA) for *Nymphoides crista, peltata* and *indica*. Personal communication to A. Tasker on October 28, 2010, from Rick Iverson, North Carolina Department of Agriculture and Consumer Services, Weeds Specialist.

Kartesz, J. 2012. Floristic Synthesis of North America by Biota of North America Program (BONAP), Version 1.0. Biota of North America Program. http://www.bonap.org/index.html. (Archived at PERAL).

Kelly, J., and C. M. Maguire. 2009. Fringed Water Lily (*Nymphoides peltata)* Invasive Species Action Plan. Northern Ireland Environment Agency and National Parks and Wildlife Service. 14 pp.

Koop, A., L. Fowler, L. Newton, and B. Caton. 2012. Development and validation of a weed screening tool for the United States. Biological Invasions 14(2):273-294.

Larson, D. 2007. Reproduction strategies in introduced *Nymphoides peltata* populations revealed by genetic markers. Aquatic Botany 86:402-406.

Maki, K., and S. Galatowitsch. 2004. Movement of invasive aquatic plants into Minnesota (USA) through horticultural trade. Biological Conservation 118(3):389-396.

Martin, P. G., and J. M. Dowd. 1990. A protein sequence study of the dicotyledons and its relevance to the evolution of the legumes and nitrogen fixation. Australian Systematic Botany 3:91-100.

Missouri Botanical Garden. 2011. Gardening help: *Nymphoides peltata*. Missouri Botanical Garden. http://www.missouribotanicalgarden.org/gardens-gardening/your-garden/plant-finder/plant-details/kc/a194/nymphoides-peltata.aspx. (Archived at PERAL).

Nault, M. E., and A. Mikulyuk. 2009. Yellow Floating Heart (*Nymphoides peltata*): A Technical Review of Distribution, Ecology, Impacts, and Management. PUB-SS-1051. Wisconsin Department of Natural Resources Bureau of Science Services, Madison, Wisconsin. 14 pp.

NGRP. 2012. Germplasm Resources Information Network (GRIN). United States Department of Agriculture, Agricultural Resources Service, National Germplasm Resources Program (NGRP). http://www.ars-grin.gov. (Archived at PERAL).

Nickrent, D. 2009. The Parasitic Plant Connection. Southern Illinois University. http://www.parasiticplants.siu.edu/. (Archived at PERAL).

NRCS. 2012. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. National Plant Data Center, Baton Rouge. Last accessed January 14, 2009, http://plants.usda.gov/java/nameSearch.

Pieterse, A. H., and K. J. Murphy. 1990. Aquatic Weeds: The Ecology and Management of Nuisance Aquatic Vegetation. Oxford University Press, New York. 593 pp.

Pond and Water Gardening. 2008. Pond and Water Gardening: *Nymphoides peltata*. Last accessed December 15, 2012, http://en.allexperts.com/q/Pond-Water-Gardening-731/2008/1/nymphoides-peltata.htm.

Reed, C. F. 1977. Economically Important Foreign Weeds: Potential problems in the United states. Agricultural Research Service, United States Department of Agriculture., U.S.A. 746 pp.

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Elchbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters (eds.). 1999. Terrestrial Ecosystems of North America-A conservation assessment. Island Press, Washington, D.C. 485 pp.

San Marcos Growers. 2011. *Nymphoides peltata* (Aquatic) - Water Fringe. http://www.smgrowers.com/products/plants/plantdisplay.asp?plant_id=1980. (Archived at PERAL).

Smits, A. J. M., R. van Ruremonde, and G. van der Velde. 1989. Seed dispersal of three nymphaeid macrophytes. Aquatic Biology 35:167-180.

Titinschneider, V., N. Patriche, M. Tenciu, C. Savin, and S. Popa. 2008. Ecological control equipment and technology of underwater vegetation development. Zootehnie si Biotehnologii 41(2):175-181.

Uesugi, R., J. Nishihiro, Y. Tsumura, and I. Washitani. 2007. Restoration

of genetic diversity from soil seed banks in a threatened aquatic plant, *Nymphoides peltata*. Conservation Genetics 8:111-121.

UF IFAS. 2011. Yellow floating heart, *Nymphoides peltata*: Non-native to Florida. University of Florida Institute of Food and Agricultural Sciences (UF IFAS), Center for Aquatic and Invasive Plants. http://plants.ifas.ufl.edu/node/294. (Archived at PERAL).

University of Minnesota. 2008. Plant information online. University of Minnesota. https://plantinfo.umn.edu/arboretum/default.asp. (Archived at PERAL).

van der Velde, G. 1976. The significance of nymphaeid water plants for animal life. Netherlands Journal of Zoology 26(3):445-446.

van der Velde, G., and L. A. v. d. Heijden. 1981. The floral biology and seed production of *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae). Aquatic Biology 10:261-293.

Wang, Y., Q. Wang, Y. Guo, and S. C. H. Barrett. 2005. Reproductive consequences of interactions between clonal growth and sexual reproduction in *Nymphoides peltata:* a distylous aquatic plant. New Phytologist 165:329-336.

Zhonghua, W., Y. Dan, T. Manghui, W. Qiang, and X. Wen. 2007. Interference between two floating-leaved aquatic plants: *Nymphoides peltata* and *Trapa bispinosa*. Aquatic Biology 86(4):316-320.

Appendix A. Weed risk assessment for *Nymphoides peltata* (S. G. Gmel.) Kuntze (Menyanthaceae). The following information was obtained from the species' risk assessment, which was conducted using the Microsoft Excel. The information shown in this appendix was modified to fit on the page. The original Excel file, the full questions, and the guidance to answer the questions are available upon request.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Invasiveness elsewhere)	f - negl	5	*Nymphoides peltata* has expanded its range in the New England states of the United States; it has escaped from cultivation and become naturalized in a number of localities in New York and Missouri (Countryman, 1970). *Nymphoides peltata* was first introduced deliberately in Sweden in the late 19th century; in several of the more than 30 lakes and watercourses distributed over 19 larger water-systems where it has been found, it forms dense stands over such large areas that control measures are necessary (Larson, 2007). It has become well established east of Tallahassee in Lake Cam; the original plants came from a local outdoor improvement center and were placed in an ornamental pond; subsequent flooding led to the spread of the plant to the lake nearby (UF IFAS, 2011). *Nymphoides peltata* has been observed in Massachusetts as being very aggressive and capable of rapid growth and spread (DCR, 2011). A single fragment of this plant is capable of colonizing an entire water body within a few years (Kelly and Maguire, 2009). Alternate answers for Monte Carlo simulation are both e.
ES-2 (Domesticated to reduce weed potential)	n - low	0	No evidence and well studied.
ES-3 (Weedy congeners)	y - negl	1	*Nymphoides humboldtianum* is a principle weed in Suriname (Holm et al., 1979). *Nymphoides indicum* is a serious weed that is being controlled in India (Reed, 1977).
ES-4 (Shade Tolerance)	n - negl	0	It grows in full sun to partial shade (Dave's Garden, 2012; San Marcos Growers, 2011). The germination of *Nymphoides peltata* seeds is also greatly stimulated by light (Smits et al., 1989).
ES-5 (Climbing or smothering growth form)	n - negl	0	It is a shallow-rooted, rhizomatous aquatic plant (eFlora, 2009; San Marcos Growers, 2011).
ES-6 (Dense Thickets)	y - negl	2	*Nymphoides peltata* forms dense single-species stands (DCR, 2011; Kelly and Maguire, 2009). An aquatic growing in dense patches (ISSG, 2012).
ES-7 (Aquatic)	y - negl	1	Is an aquatic bottom-rooted perennial (eFlora, 2009; ISSG, 2012).
ES-8 (Grass)	n - negl	0	*Nymphoides peltata* is in the Family Menyanthaceae, and is not a grass (NGRP, 2012).
ES-9 (N2-fixer)	n - negl	0	Not in a plant family known to have N-fixing capabilities (Martin and Dowd, 1990).
ES-10 (Viable seeds)	y - negl	1	The incompatibility system of *N. peltata* is weak, so that self-pollinations invariably result in the formation of small capsules producing 10-20 seeds (van der Velde and Heijden, 1981). However, in dimorphic populations, production of more than 3000 seeds per square meter has been observed. Though seeds from self-pollinations germinate easily, seedling

Question ID	Answer - Uncertainty	Score	Notes (and references)
			viability appears to be low (van der Velde and Heijden, 1981).
ES-11 (Self-compatible)	y - high	1	The literature is somewhat confounded; however, the preponderance of the data supports selfing and inbreeding among ramets and the opposing author has left the door open for the possibility of selfing and intramorph fertilizations. One genetic study suggests that the sampled seed banks of *N. peltata* were produced by inbreeding and/or a predominance of self-fertilization (Larson, 2007; Uesugi et al., 2007). *Nymphoides peltata* has a homostylous morph type occurring at a low frequency that can self-fertilize (Uesugi et al., 2007; van der Velde and Heijden, 1981). *Nymphoides peltata* has a weak self-incompatilility system (van der Velde and Heijden, 1981). Experimental pollinations indicate that *N. peltata* possesses a strong dimorphic incompatibility system preventing self and intramorph fertilizations (Wang et al., 2005). However, because of the wide geographical range of *N. peltata*, further studies are required before it can be safely concluded that distyly (and possibly selfing) is the exclusive sexual system of this species (Wang et al., 2005). Note: This species has two floral types (floral morphs) that typically are sexually incompatible.
ES-12 (Special Pollinators)	n - negl	0	*Nymphoides peltata* is pollinated by species of Apidae, Syrphidae, and Ephydridae; therefore, it does not require specialized pollinators (van der Velde and Heijden, 1981). Flowers are visited by a wide range of insect pollinators, mostly bees and flies (Wang et al., 2005).
ES-13 (Min generation time)	a - low	2	*Nymphoides peltata* has a high growth rate due to its fast and abundant production of new, densely packed ramets; in the present study, it produced about 102 ramets per plant in just 12 weeks (Zhonghua et al., 2007). When attempts have been made to mechanically remove plants by cutting the leaf petioles, the plants will form new leaves, and one or two cuts may be necessary each spring and summer to control its expansion (CEH, 2004). Alternate answers for Monte Carlo simulation are both b.
ES-14 (Prolific reproduction)	n - high	-1	In dimorphic natural populations, production of more than 3,000 seeds per square meter has been observed (Larson, 2007; van der Velde and Heijden, 1981) while *Nymphoides peltata* plants grown in experimental tanks have been observed to produce 9,434 seeds per square meter (van der Velde and Heijden, 1981). Answering no based on the field evidence, but using high uncertainty due to the laboratory evidence.
ES-15 (Unintentional dispersal)	y - negl	1	*Nymphoides peltata* has escaped from cultivation and has spread to multiple locations in New York and Missouri (Countryman, 1970). When grown in outdoor water gardens, it can spread unintentionally to new areas by water during heavy rains (ISSG, 2012; UF IFAS, 2011).
ES-16 (Trade contaminant)	? - max	0	There is no evidence available about *N. peltata* being moved as a trade contaminant, but aquatic plants are commonly moved as contaminants of plants in the water garden trade (Maki and Galatowitsch, 2004) so answering "unknown."
ES-17 (#Natural dispersal vectors)	2 -	0	Fruit/seed description to support the next five questions: Fruit is a capsule up to 2.5 cm long, containing numerous seeds

Question ID	Answer - Uncertainty	Score	Notes (and references)
			about 3.5 mm long with hairy edges (ISSG, 2012).
ES-17a (Wind dispersal)	n - negl		No evidence, well studied. "Though it has been suggested that wind may be a vector in the dispersal of *N. peltata*, this is not the case…While floating, the seeds occupy the air-water interface and are not moved by wind" (Cook, 1990).
ES-17b (Water dispersal)	y - negl		Seed hairs help it to float and be dispersed mainly by water (hydrochory) (Countryman, 1970; ISSG, 2012; Smits et al., 1989).
ES-17c (Bird dispersal)	y - negl		The seed hairs of *Nymphoides peltata* allow for attachment to and dispersal by waterfowl (Countryman, 1970; ISSG, 2012; Smits et al., 1989). The seeds are picked up by some parts of waterfowl, such as the flanks, the region between bill and eyes and the web of the feet of the mallard, and the bill and shield of the coot ((Cook, 1990). The seeds of *N. peltata* are thin-walled and destroyed by fish and waterfowl during digestions and thus unsuitable for endozoochory (Cook, 1990).
ES-17d (Animal external dispersal)	n - negl		No evidence and well studied.
ES-17e (Animal internal dispersal)	n - low		No evidence and well studied. The seeds are thin-walled and digested by fish and waterfowl and thus unsuitable for endozoochory (Cook, 1990). Apparently, the seed coat of *Nymphoides peltata* are too weak to withstand the mechanical and chemical digestion by birds and fish and as a consequence are completely destroyed (Smits et al., 1989).
ES-18 (Seed bank)	y - mod	1	Along lakeshores, natural seedling emergence from seed banks of *N. peltata* continues several years after the adult subpopulation has died out (eFlora, 2009).
ES-19 (Tolerance to loss of biomass)	y - low	1	If plants reproduce vegetatively, repeated cutting of *N. peltata* can increase the population's spread since plant fragments can regrow to establish new colonies (Larson, 2007).
ES-20 (Herbicide resistance)	n - mod	0	No evidence of resistance from (Heap, 2011), but at least one gardener has said that herbicides were ineffective at controlling *N. peltata* (Pond and Water Gardening, 2008). Going with no and using moderate uncertainty because of complaint from gardener.
ES-21 (# Cold hardiness zones)	8	0	
ES-22 (# Climate types)	6	2	
ES-23 (# Precipitation bands)	9	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - negl	0	There is no evidence of allelopathy for aquatic plants.
Imp-G2 (Parasitic)	n - negl	0	*Nymphoides peltata* is not in a plant family known to have members with parasitic traits (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Ecosystem processes)	y - negl	0.4	It is an aquatic whose growth decreases the oxygen levels causing stagnant areas under the floating mats; additionally, it excludes light availability to an ecosystem and increases sediment (DCR, 2011; ISSG, 2012; Kelly and Maguire, 2009; van der Velde, 1976).
Imp-N2 (Community structure)	y - negl	0.2	*Nymphoides peltata* forms dense single species stands (DCR, 2011; Kelly and Maguire, 2009) and disrupts the entire food web in a lake (DCR, 2011).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N3 (Community composition)	y - negl	0.2	*Nymphoides peltata* displaces native species; thus reducing biodiversity (DCR, 2011; Kelly and Maguire, 2009). Its ability to exclude light and oxygen adversely impacts native species, notably phytoplankton in freshwater aquatic systems (ISSG, 2012). In areas with mild winter conditions, plants can spread somewhat aggressively to the point of crowding out native species (Missouri Botanical Garden, 2011).
Imp-N4 (T&E species)	y - low	0.1	Given the impacts described above, it is likely to negatively impact Threatened and Endangered species in the United States.
Imp-N5 (Globally outstanding ecoregions)	y - low	0.1	It has the potential to endanger Outstanding Ecoregions in CA, AZ, and PA (Ricketts et al., 1999).
Imp-N6 (Natural systems weed)	c - negl	0.6	In water bodies in Massachusetts, *N. peltata* is managed with mechanical removal and herbicide application (DCR, 2011). New Zealand, Canada, and the U.S. states of Washington, Maine, New Hampshire, Connecticut, Vermont, and South Carolina are regulating it (Countryman, 1970; ISSG, 2012). In Ireland where it disrupts ecosystems, plant sales are prohibited in an ongoing effort to eradicate or control it (Kelly and Maguire, 2009). Alternate answers for Monte Carlo simulation are both b.
Impact to Anthropogenic areas (cities, suburbs, roadways)			
Imp-A1 (Affects property, civilization, ...)	n - mod	0	No evidence.
Imp-A2 (Recreational use)	y - low	0.1	"Thick floating mats can entirely prevent fishing, boating, swimming and other activities and the loss of recreational and aesthetic value can cause a decline in surrounding lake property value" (DCR, 2011).
Imp-A3 (Affects ornamental plants)	? - max		Unknown
Imp-A4 (Anthropogenic weed)	c - low	0.4	A gardener inquires, "I was hoping you could help me with the highly invasive plant *Nymphoides peltata*. For the last year I have tried to remove this lily from a pond. I have tried herbicides and pulling out the root systems" (Pond and Water Gardening, 2008). This plant is considered as possibly noxious on a garden website (Dave's Garden, 2012). *N. peltata* sales, including sales to garden centers, supermarkets, aquarists, and other retail outlets, have been prohibited in Ireland in an ongoing effort to eradicate or control it from further spread; the government encourages individuals to remove and destroy *N. peltata* voluntarily from ponds and aquaria (Kelly and Maguire, 2009). Alternate answers for Monte Carlo simulation are both b.
Impact to Production systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Crop yield)	y - low	0.4	*Nymphoides indica* plants can reduce the available rearing area in fish production farms (Titinschneider et al., 2008).
Imp-P2 (Commodity Value)	? - max		Unknown.
Imp-P3 (Affects trade)	? - max		*Nymphoides peltata* is regulated in at least six U.S. states (NRCS, 2012), Saskatchewan, Canada (Bjornerud, 2010), Ireland, and New Zealand, (Kelly and Maguire, 2009). There is no evidence available about *N. peltata* being moved as a trade contaminant, but aquatic plants are commonly moved as contaminants of plants in the water garden trade (Maki and

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Galatowitsch, 2004) so answering "unknown."
Imp-P4 (Irrigation)	? - max		There is no evidence for this species, but because many aquatic plants affect irrigation (Pieterse and Murphy, 1990), answer this question as unknown.
Imp-P5 (Animal toxicity)	n - low	0	No evidence and well studied (Burrows and Tyrl, 2001).
Imp-P6 (Production system weed)	c - low	0.6	*Nymphoides peltata* is actively controlled for removal from fish farms when excess growth negatively impacts the yields on fish farms (Titinschneider et al., 2008). In Romania *Nymphoides peltata* is harvested by fish farmers because it disrupts the oxygen content of the water, which negatively impacts fish hatchlings (Cazacu and Gache, 2005). Alternate answers for Monte Carlo simulation are both b.
GEOGRAPHIC POTENTIAL			
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	No evidence.
Geo-Z2 (Zone 2)	n - negl	N/A	No evidence.
Geo-Z3 (Zone 3)	n - negl	N/A	No evidence.
Geo-Z4 (Zone 4)	y - high	N/A	PS: China (Sichuan) (GBIF, 2012).
Geo-Z5 (Zone 5)	y - negl	N/A	PS: North Korea, Vermont (GBIF, 2012).
Geo-Z6 (Zone 6)	y - negl	N/A	PS: South Korea, Sweden, WA (GBIF, 2012); Occ: (Dave's Garden, 2012).
Geo-Z7 (Zone 7)	y - negl	N/A	PS: South Korea, Poland (GBIF, 2012); Occ: (Dave's Garden, 2012).
Geo-Z8 (Zone 8)	y - negl	N/A	PS: India, France (GBIF, 2012); Occ: (Dave's Garden, 2012).
Geo-Z9 (Zone 9)	y - negl	N/A	PS: France, California (GBIF, 2012); Occ: (Dave's Garden, 2012).
Geo-Z10 (Zone 10)	y - low	N/A	Occ: (Dave's Garden, 2012).
Geo-Z11 (Zone 11)	y - mod	N/A	Occ: (Dave's Garden, 2012).
Geo-Z12 (Zone 12)	n - high	N/A	No evidence.
Geo-Z13 (Zone 13)	n - low	N/A	No evidence.
Koppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	No evidence.
Geo-C2 (Tropical savanna)	n - negl	N/A	No evidence.
Geo-C3 (Steppe)	y - low	N/A	PS: France (GBIF, 2012).
Geo-C4 (Desert)	n - negl	N/A	No evidence.
Geo-C5 (Mediterranean)	y - negl	N/A	PS: Spain (GBIF, 2012).
Geo-C6 (Humid subtropical)	y - negl	N/A	PS: Texas, Japan (GBIF, 2012).
Geo-C7 (Marine west coast)	y - low	N/A	PS: China (Yunan), France (GBIF, 2012).
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	PS: Illinois, South Korea (GBIF, 2012).
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	PS: New York, China (Sichuan), Sweden (GBIF, 2012).
Geo-C10 (Subarctic)	n - low	N/A	No evidence.
Geo-C11 (Tundra)	n - negl	N/A	No evidence.
Geo-C12 (Icecap)	n - negl	N/A	No evidence.
10-inch precipitation bands			
Geo-R1 (0-10")	n - negl	N/A	No evidence.
Geo-R2 (10-20")	n - high	N/A	No evidence.
Geo-R3 (20-30")	y - negl	N/A	PS: Sweden, Texas (GBIF, 2012).
Geo-R4 (30-40")	y - negl	N/A	PS: India, Denmark (GBIF, 2012).
Geo-R5 (40-50")	y - negl	N/A	PS: North Korea, Australia (GBIF, 2012).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R6 (50-60")	y - negl	N/A	PS: South Korea, Australia (GBIF, 2012).
Geo-R7 (60-70")	y - negl	N/A	PS: Japan, United Kingdom (GBIF, 2012).
Geo-R8 (70-80")	y - negl	N/A	PS: Japan, United Kingdom (GBIF, 2012).
Geo-R9 (80-90")	y - negl	N/A	PS: United Kingdom (GBIF, 2012).
Geo-R10 (90-100")	y - low	N/A	Occurs in areas where 89-90 inches of rainfall occur and in areas where 100+ inches of rainfall occur (GBIF, 2012), so it follows that *N. peltata* can also survive in areas where 90-100 inches of rainfall occur.
Geo-R11 (100"+)	y - low	N/A	PS: United Kingdom (GBIF, 2012).
ENTRY POTENTIAL			
Ent-1 (Already here)	y - negl	1	Occurs in 25 states of the United States (Kartesz, 2012; NRCS, 2012).
Ent-2 (Proposed for entry)		N/A	
Ent-3 (Human value & cultivation/trade status)		N/A	
Ent-4 (Entry as a Contaminant)			
Ent-4a (In MX, CA, Central Amer., Carib., or China)		N/A	
Ent-4b (Propagative material)		N/A	
Ent-4c (Seeds)		N/A	
Ent-4d (Ballast water)		N/A	
Ent-4e (Aquaria)		N/A	
Ent-4f (Landscape products)		N/A	
Ent-4g (Container, packing, trade goods)		N/A	
Ent-4h (Commodities for consumption)		N/A	
Ent-4i (Other pathway)		N/A	
Ent-5 (Natural dispersal)		N/A	