Weed Risk Assessment for *Neptunia oleracea* Lour. (Fabaceae) – Water mimosa

United States Department of Agriculture

Animal and Plant Health Inspection Service

June 14, 2012

Version 1

Top left: *Neptunia oleracea* plants in flower; top right: Spongy, floating stem tissue of *Neptunia oleracea*; bottom: A colony of *Neptunia oleracea* plants (source: Technigro, 2011).

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 "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[1]—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 our 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 any area within it. We use a climate matching tool in our WRAs to evaluate those areas of the United States that are suitable for the establishment of the plant. We also use a Monte Carlo simulation to evaluate the consequences of uncertainty on the outcome of the risk assessment. For more information on the PPQ WRA process, please refer to the document, *Introduction to the PPQ Weed Risk Assessment Process*, which is available upon request.

***Neptunia oleracea* Lour. – Water mimosa**
Species Family: Fabaceae
Information Initiation: On October 27, 2011, the Exotic Pest Information Collection and Analysis (EPICA) program reported that a population of *Neptunia oleracea* had been found in Arkansas in 2009, in the Little Maumelle River, along the Arkansas River flood plain (Peck and Serviss, 2011). This was the first detection of naturalized populations of *N. oleracea* in the United States. Joel Bard, the Arkansas State Plant Health Director, is concerned that stem fragments of *N. oleracea* could move downstream, allowing the plant to establish in more favorable, warmer areas of the United States.
Foreign distribution: *Neptunia oleracea* is thought to be native to South America and introduced to other areas of the world (Bentham, 1875). *Neptunia oleracea* now occurs in Mexico and in over 50 countries in Central and South America, the Caribbean, Africa, and Asia (Windler, 1966).
U.S. distribution and status: A colony of *N. oleracea* was detected in Arkansas in 2009 (Peck and Serviss, 2011). James Peck, professor of biology at Arkansas State University, says that a few stem fragments could still be found in 2011 (Peck and Serviss, 2011). *Neptunia oleracea* is available through the water garden and aquarium trade (Peck and Serviss, 2011; Ponds Plants and More, 2011; The Flowering Garden, 2011; The Water Garden, 2011Ponds Plants and More, 2011 #46}), so it may be present in other states in cultivation.
WRA area: Entire United States, including territories

[1] 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. DOI:10.1007/s10530-011-0061-4

1. *Neptunia oleracea* analysis

Establishment/Spread Potential

Neptunia oleracea is a nitrogen-fixing aquatic plant (Yanasugondha and Buranakarl, 1981) that roots on the edges of water bodies and then forms dense, floating mats of stems that spread rapidly over the water surface (Peck and Serviss, 2011; Windler, 1966). This plant is native to South America and has naturalized in over 50 countries in South and Central America, Africa, and Asia (Windler, 1966). *Neptunia oleracea* is propagated by seeds and stem fragments that are dispersed by water (Australian Weeds Committee, 2011; Technigro, 2011), therefore mutilation facilitates the spread of this species. People can spread seeds in mud attached to machinery and vehicles (Technigro, 2011). This risk element had average (moderate) uncertainty because we could not answer questions about the number of seeds produced, minimum generative time, and if *N. oleracea* can form seed banks.
Risk score = 14 Uncertainty index = 0.18

Impact Potential

Neptunia oleracea produces dense, floating mats that can replace native wetland plants, block water flow in creeks and drains, restrict boat access, reduce water quality, and kill native plants and fish (Australian Weeds Committee, 2011; Queensland Government, 2009). *Neptunia oleracea* is listed as a Class 1 Pest Plant (introduction into the state is prohibited, and landowners must take reasonable steps to keep land free of this species) in Queensland, Australia (Queensland Government, 2009), where it is controlled in natural ecosystems through mechanical and chemical controls (Technigro, 2011). In urban/suburban environments, it restricts boat access, blocks drains, and creates a favorable habitat for certain species of mosquitoes (Queensland Government, 2009). *Neptunia oleracea* has also been reported as a weed of rice fields in southeast Asia (IRRI, 1993; Moody, 1989). This risk element had an average amount of uncertainty.
Risk score = 3.1 Uncertainty index = 0.12

Geographic Potential

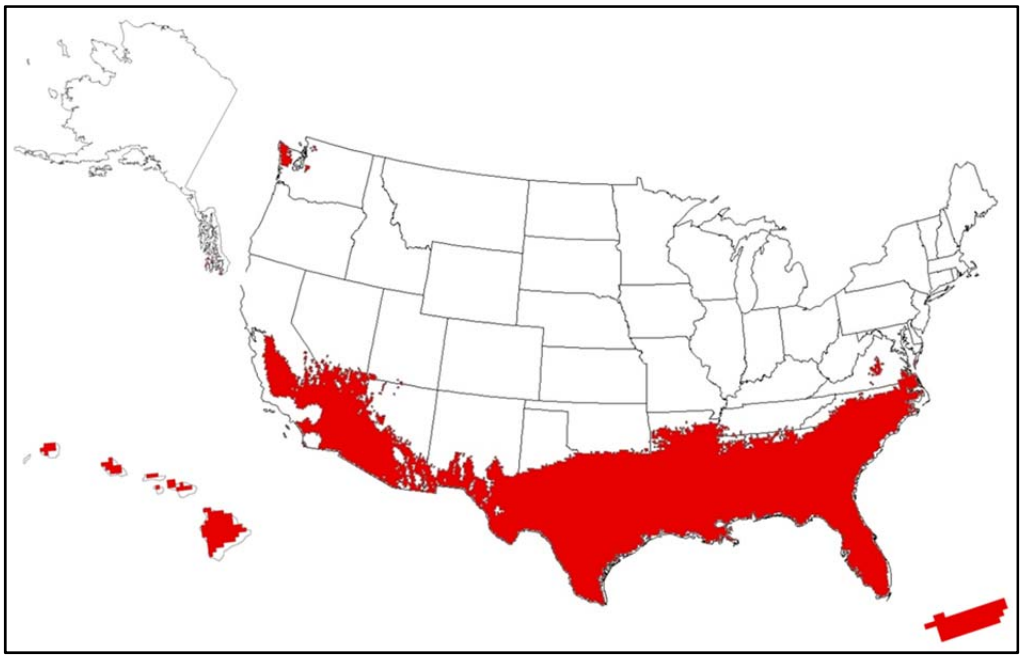
Neptunia oleracea is an aquatic plant that grows in wetlands, bodies of fresh water, and slow-running tropical rivers (Bentham, 1875; Windler, 1966). To evaluate its potential distribution in the United States, we had to determine if it could survive the winters where it was found in the Little Maumelle River in Arkansas, a region in USDA Plant Hardiness Zone 8. We consulted with Dr. Brett Serviss, a plant biologist at Henderson State University who co-authored the paper reporting the Arkansas colony of *N. oleracea*. Dr. Serviss thought that *N. oleracea* might be able to overwinter in Arkansas during warm winters if the water did not freeze, but he did not think that the *N. oleracea* colony would be able to expand and spread in Arkansas (Serviss, 2011). However, Dr. James Peck, the biology professor from Arkansas State University who found the Arkansas colony, reported that a few stem fragments of the original Arkansas colony remain, suggesting that, at least for the last few years, it has been able to survive cold winter temperatures (Peck, 2011). He reports that stem fragments seem to sink into the water in the fall, thus avoiding the freezing ice. It is also possible, however, that the population has survived only because it is recolonized by people growing the plant as a vegetable. In our analysis, we assumed that *N. oleracea* can survive in Plant Hardiness Zone 8.

We estimate that about 20 percent of the United States is suitable for the establishment of *N. oleracea* (Fig. 1). The predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence (GBIF, 2011). The map for *Neptunia oleracea*

includes the joint distribution of USDA Plant Hardiness Zones 8-13, areas with 0-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, steppe, desert, humid subtropical, and marine west coast.

Entry Potential We did not assess entry potential because *N. oleracea* has already naturalized in Arkansas (Peck and Serviss, 2011) and is cultivated in U.S. aquariums and water gardens (The Water Garden, 2011; The Flowering Garden, 2011; Ponds Plants and More, 2011).

Figure 1. Predicted distribution of *Neptunia oleracea* 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) = 73.7%
P(Minor Invader) = 25.3%
P(Non-Invader) = 1.1%

Risk Result = High Risk

Secondary Screening = Not applicable

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

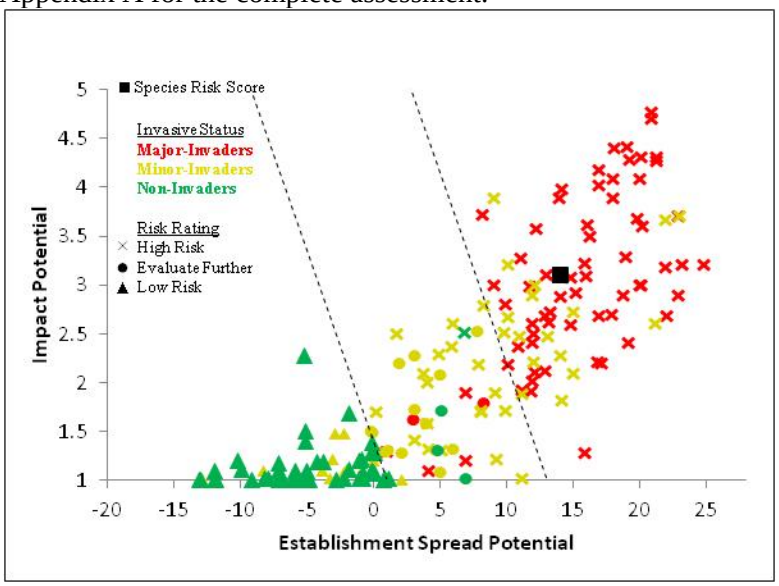
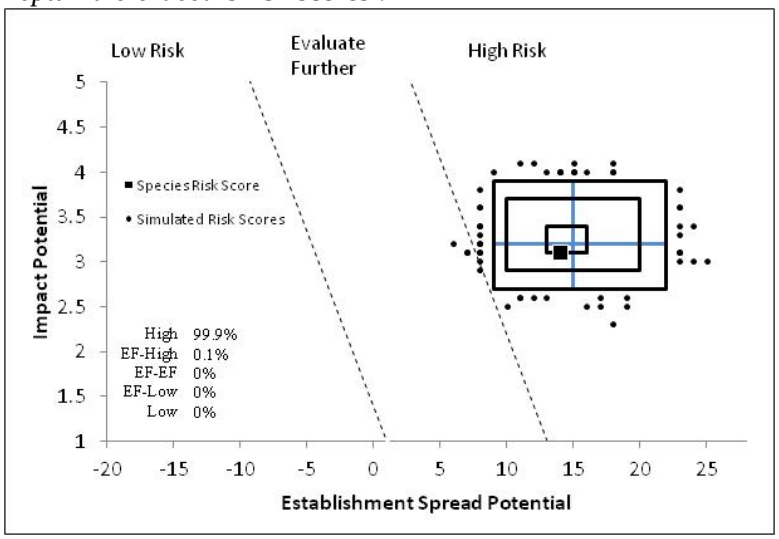


Figure 3. Monte Carlo simulation results (N=5000) for uncertainty around *Neptunia oleracea*'s risk scores[a].



[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 WRA for *N. oleracea* is High Risk. *Neptunia oleracea* is a floating aquatic plant that spreads quickly over the surface of fresh bodies of water and replaces native wetland plants, blocks water flow in creeks and drains, restricts boat access, and reduces water quality (Queensland Government, 2009). Comparison of *N. oleracea* to the 204 species used in the validation study indicates that it shares many of the same traits and impacts as other major- and high-scoring minor-invaders (Fig. 2). In the uncertainty analysis, the simulated risk scores all resulted in a conclusion of High Risk (Fig. 3), indicating that the overall model conclusion is highly robust. In this WRA, we considered Plant Hardiness Zones 8 and above as suitable for the establishment of *Neptunia oleracea*. If only Zones 9 and higher are suitable for this species, then we estimate that approximately 6 percent (versus 20 percent) of the United States is suitable for this species. Concern exists that stem fragments of *N. oleracea* could move downstream from their current location into warmer, more favorable habitats where they could become permanently established (Bard, 2011). *Neptunia oleracea* is not known to be established in any other parts of the United States, but this species is available for sale as a water garden and aquarium plant (The Water Garden, 2011; Ponds Plants and More, 2011).

4. Literature Cited

Australian Weeds Committee. 2011. Weed Identification. Australia. Water Mimosa Australian Weeds Strategy, Australia. Last accessed October 28, 2011, http://www.weeds.org.au/cgi-bin/weedident.cgi?tpl=plant.tpl&state=&s=&ibra=all&card=W30.

Bard, J. W. 2011. Personal communication to A. Koop and L. Kohl on November 4, 2011, from Joel Bard, Arkansas State Plant Health Director, regarding an Arkansas population of *Neptunia oleracea*.

Bentham, G. 1875. Revision of the suborder Mimoseae. Pages 335-664 Transactions of the Linnean Society of London. Volume 30, London, United Kingdom.

Bhoomannavar, V. S., S. I. Shivakumar, C. S. Hallikeri, and B. C. Hatapakki. 2011. Hepatoprotective activity of leaves of *Neptunia oleracea* Lour in carbon tetrachloride induced rats. Research Journal of Pharmaceutical, Biological and Chemical Sciences 2(2):309-314.

GBIF. 2011. Data Portal. Global Biodiversity Information Facility. Last accessed September 2, http://data.gbif.org/welcome.htm.

Hannan-Jones, M., and S. Csurhes. 2008. Pest plant risk assessment: Water mimosa *Neptunia oleracea*. Dead and awake *Neptunia plena* (PR08-3686). Biosecurity Queensland, Department of Primary Industries and Fisheries, Queensland, Australia.

Heide-Jørgensen, H. S. 2008. Parasitic flowering plants. Brill Publishers, Leiden, The Netherlands. 442 pp.

IRRI. 1993. International rice research notes. Volume 18(1). International Rice Research Institute, Los Baños / Manila.

Moody, K. 1989. Weeds: reported in rice in South and Southeast Asia. International Rice Research Institute (IRRI), Manila, Philippines. 442 pp.

NAS. 1976. Making aquatic weeds useful: some perspectives for developing countries. National Academy of Sciences (NAS). Ad Hoc Panel on Utilization of Aquatic Weeds, Washington, D.C. 175 pp.

NGRP. 2011. Germplasm Resources Information Network (GRIN). United States Department of Agriculture, Agricultural Research Service, National Genetic Resources Program (NGRP). http://www.ars-grin.gov/cgi-

bin/npgs/html/index.pl?language=en. (Archived at PERAL).
Peck, J. 2011. *Neptunia oleracea* weed risk assessment. Personal communication to L. Kohl on November 6, 2011, from James Peck, Professor of Biology, Arkansas State University, regarding an Arkansas poulation of *Neptunia oleracea*.
Peck, J. H., and B. E. Serviss. 2011. *Neptunia oleracea* (Fabaceae) new to the continental United States, with new and noteworthy records of several angiosperms in Arkansas. Journal of the Botanical Research Institute of Texas 5(1):321-326.
Ponds Plants and More. 2011. PFT Water Sensitive Plant (*Neptunia oleracea*). Ponds, Plants and More, Bentleyville, Pennsylvania. Last accessed October 31, 2011, http://www.pondsplantsandmore.com/Water_Sensitive_Plant_Neptunia_oleracea_p/pft_sensitive.htm.
Queensland Government. 2009. Water mimosa *Neptunia oleracea* or *Neptunia plena*. Fact Sheet: Declared Class 1 Pest Plant (PP149). The State of Queensland, Department of Employment, Economic Development and Innovation, Queensland, Australia.
Raju, R. A. (ed.). 1999. Ethnobotany of Rice Weeds in South Asia. Today and Tomorrow's Printers and Publishers, New Delhi, India. 235 pp.
Randall, R. P. 2011. A Global Compendium of Weeds. Hawaiian Ecosystems at Risk and Department of Agriculture of Western Australia. http://www.hear.org/gcw/.
Ricketts, T. H., E. Dinerstein, D. M. Olson, and C. J. Loucks. 1999. Terrestrial ecoregions of North America: A conservation assessment. Island Press. 485 pp.
Serviss, B. 2011. Personal communication to L. Kohl on November 3, 2011, from Brett Serviss, Professor of Biology at Henderson State University, regarding the ability of *Neptunia oleracea* to overwinter in Arkansas.
Sharma, K. P., T. I. Khan, and N. Bhardwaj. 1984. Temperature-regulated seed germination in *Neptunia oleracea* Lour. and its ecological significance. Aquatic Botany 20(185-188).
Singh, B., and T. N. Shivapuri. 1935. The gametophytes of *Neptunia oleracea* Lour. Proceedings: Plant Sciences 1(8):423-434.
Technigro. 2011. Weed watch: Water mimosa (*Neptunia oleracea*). Technigro Australia, Queensland, Australia. Last accessed October 28, 2011, http://www.technigro.com.au/documents/WW%20Water%20mimosa.pdf.
The Flowering Garden. 2011. Water Mimosa (*Neptunia oleracea*) Gardening. Last accessed October 27, 2011, http://www.thefloweringgarden.com/water-mimosa.htm.
The Water Garden. 2011. Sensitive Plant. *Neptunia oleracea* The Water Garden, LLC, Chattanooga,Tennessee. Last accessed October 31, 2011, http://www.watergarden.org/s.nl/it.A/id.660/.f.
USFWS. 2011. Threatened and endangered species system (TESS). United States Fish and Wildlife Service (USFWS). http://ecos.fws.gov/tess_public/TESSWebpage. (Archived at PERAL).
Wilson. 2010. A Sensitive Plant that Swims! Gardening with Wilson: Celebrating Life in a Garden City, Singapore. Last accessed October 31, 2011, http://gardeningwithwilson.com/2010/01/07/sensitive-plant-that-swims/.
Windler, D. R. 1966. A revision of the genus *Neptunia* (Leguminosae). Australian Journal of Botany 14:379-420.
WSSA. 2007. Composite List of Weeds. Weed Science Society of America (WSSA). http://www.wssa.net/Weeds/ID/WeedNames/namesearch.php. (Archived at PERAL).
Yanasugondha, D., and L. Buranakarl. 1981. Nitrogen fixation in root nodules of *Neptunia oleracea* Lour. in water culture. Pages 148-149 Wetselaar, R.; Simpson,

J. R.; Rosswall, T.: Nitrogen cycling in south-east Asian wet monsoonal ecosystems. Australian Academy of Science, Canberra; Australia.

Appendix A. Weed risk assessment for *Neptunia oleracea* Lour. (Fabaceae). The following information was obtained from the species' risk assessment, which was conducted on a Microsoft Excel platform. The information shown below 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	"*Neptunia oleracea*…spread[s] rapidly in any slow-running tropical river or large piece of fresh water into which it may have been introduced. It was found abundantly in tropical waters …of South America, as well as of tropical Asia and Africa….We might conclude, therefore, that *N. oleracea* is a species of South American origin" (Bentham, 1875). "Once established, it spreads rapidly across the surface of the water" (Peck and Serviss, 2011). *Neptunia oleracea* is naturalized in over 50 countries in South and Central America, Africa, and Asia (Windler, 1966). Alternate answer for the Monte Carlo simulation is e.
ES-2 (Domesticated to reduce weed potential)	n - low	0	No evidence. *Neptunia oleracea* is only identified at the species level where sold (The Water Garden, 2011; Ponds Plants and More, 2011).
ES-3 (Weedy congeners)	y - low	1	The related species *Neptunia plena* is a declared Class 1 pest plant (introduction into the state is prohibited, and landowners must take reasonable steps to keep land free of this species) in Queensland, Australia (Queensland Government, 2009).
ES-4 (Shade Tolerance)	n - low	0	"Shade...adversely affect[s] plant growth" (Queensland Government, 2009).
ES-5 (Climbing or smothering growth form)	n - negl	0	*Neptunia oleracea* is not a vine (Windler, 1966; Peck and Serviss, 2011).
ES-6 (Dense Thickets)	y - negl	2	"Form[s] floating rafts of dense interwoven stems" (Queensland Government, 2009). "Water mimosa can form rafts of dense interwoven stems on the water surface....it also has the potential to restrict water flow in creeks and channels" (Technigro, 2011).
ES-7 (Aquatic)	y - negl	1	Aquatic plant in the family Fabaceae (NGRP, 2011).
ES-8 (Grass)	n - negl	0	Aquatic plant in the family Fabaceae (NGRP, 2011).
ES-9 (N2-fixer)	y - negl	1	Nitrogen-fixing aquatic plant in the family Fabaceae (NGRP, 2011; Yanasugondha and Buranakarl, 1981).
ES-10 (Viable seeds)	y - negl	1	Propagated by seeds (Raju, 1999; Sharma et al., 1984).
ES-11 (Self-compatible)	y - high	1	The related species *N. major*, *N. monosperma*, *N. pubescens*, and *N. plena* are self-fertile (Windler, 1966).
ES-12 (Special Pollinators)	n - low	0	Flowers attract insect pollinators (Singh and Shivapuri, 1935). No evidence found that *N. oleracea* requires specialist pollinators.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-13 (Min generation time)	? - max		Unknown. Propagated by stem fragments (Technigro, 2011). One blogger says that his *N. oleracea* stem fragments began rooting and extending after just one week in water (Wilson, 2010). "The plant is usually described as a perennial aquatic herb" (Yanasugondha and Buranakarl, 1981). Alternate answer for the Monte Carlo simulation is "?".
ES-14 (Prolific reproduction)	? - max	0	Unknown. Four to eight seeds per legume (Windler, 1966). "The plant produces large numbers of seeds" (Sharma et al., 1984).
ES-15 (Unintentional dispersal)	y - low	1	"Seeds may also be dispersed in mud attached to machinery or vehicles" (Technigro, 2011).
ES-16 (Trade contaminant)	n - mod	-1	No evidence.
ES-17 (#Natural dispersal vectors)	1 -	-2	Seed description used to help answer the next five questions: “Seeds 4-8 per legume, brown, ovoid, compressed, 4.0-5.1 mm long, 2.7-3.5 mm broad” (Windler, 1966).
ES-17a (Wind dispersal)	n - negl		No evidence. Seeds produced in a legume pod with no adaptations for wind dispersal (Windler, 1966).
ES-17b (Water dispersal)	y - negl		"Spread by...water movement of stems" (Australian Weeds Committee, 2011).
ES-17c (Bird dispersal)	n - mod		No evidence. Seeds produced in a legume pod with no obvious reward for birds (Windler, 1966).
ES-17d (Animal external dispersal)	n - mod		No evidence. Seeds produced in a legume pod with no adaptations to adhere to animals (Windler, 1966).
ES-17e (Animal internal dispersal)	n - mod		No evidence.
ES-18 (Seed bank)	? - max	0	Unable to find information about long-term seed dormancy. Seeds require two cycles of alternating high and low temperatures to break dormancy, but in nature these conditions required for breaking seed dormancy would occur within 12 months of seed production (Sharma et al., 1984).
ES-19 (Tolerance to loss of biomass)	y - low	1	Mutilation facilitates the spread of *N. oleracea* because this species reproduces by stem fragments (Technigro, 2011).
ES-20 (Herbicide resistance)	n - mod	0	No evidence (WSSA, 2007).
ES-21 (# Cold hardiness zones)	6	0	
ES-22 (# Climate types)	6	2	
ES-23 (# Precipitation bands)	11	1	
Impact Potential			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	No evidence.
Imp-G2 (Parasitic)	n - negl	0	No evidence. *Neptunia oleracea* is an aquatic plant in the family Fabaceae, a plant family not known to contain parasitic species (Heide-Jørgensen, 2008).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Impacts to Natural Systems			
Imp-N1 (Ecosystem processes)	y - low	0.4	Floating rafts can "reduce water quality by preventing light penetration and reducing oxygenation of water" (Queensland Government, 2009). "Plants fix nitrogen so may impact water quality" (Australian Weeds Committee, 2011).
Imp-N2 (Community structure)	y - low	0.2	Adds a new layer to an ecosystem by forming dense, floating mats of stems over the surface of bodies of water (Queensland Government, 2009).
Imp-N3 (Community composition)	y - negl	0.2	Floating rafts can "cause the death of native, submerged water plants and fish" and "replace native wetland plants" (Queensland Government, 2009). "[I]t can replace native water plants and cause the death of submerged plants and fish" (Technigro, 2011).
Imp-N4 (T&E species)	y - low	0.1	Forms dense floating mats over water surfaces that "cause the death of native, submerged water plants and fish" and "replace native wetland plants" (Queensland Government, 2009), so *N. oleracea* is likely to impact Threatened and Endangered wetland species in the United States, such as the aquatic plant *Potamogeton clystocarpus* in Texas (USFWS, 2011).
Imp-N5 (Globally outstanding ecoregions)	y - low	0.1	*Neptunia oleracea* grows in "water bodies, slow-moving waterways, wetlands, and other damp sites" (Technigro, 2011), so this species would be able to affect globally outstanding ecoregions such as wetlands in the southern United States (Ricketts et al., 1999).
Imp-N6 (Natural systems weed)	c - negl	0.6	Controlled in natural ecosystems in Australia by mechanical and chemical methods (Technigro, 2011). *Neptunia oleracea* is a regulated Class 1 pest plant in Queensland, Australia (Queensland Government, 2009). Alternate answer for the Monte Carlo simulation is b.
Impact to Anthropogenic areas (cities, suburbs, roadways)			
Imp-A1 (Affects property, civilization, ...)	y - low	0.1	Floating rafts can "restrict water flow in creeks, channels and drains" and "create a favourable habitat for mosquitoes" (Queensland Government, 2009). "Neptunia spp. may increase water loss from dams through increased evaporation via water transpiration through its leaves" (Hannan-Jones and Csurhes, 2008).
Imp-A2 (Recreational use)	y - low	0.1	Floating rafts can "impede recreational water sports and boating access" (Queensland Government, 2009).
Imp-A3 (Affects ornamental plants)	n - mod	0	No evidence.
Imp-A4 (Anthropogenic weed)	b - mod	0.1	Listed as a weed by (Randall, 2011) but no information found about control in recreational

Question ID	Answer - Uncertainty	Score	Notes (and references)
			areas/urban areas. Alternate answers for the Monte Carlo simulation are c, then a.
Impact to Production systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Crop yield)	n - mod	0	No evidence.
Imp-P2 (Commodity Value)	n - mod	0	No evidence.
Imp-P3 (Affects trade)	n - mod	0	No evidence.
Imp-P4 (Irrigation)	? - max		*Neptunia oleracea* "tends to invade irrigation ditches" (NAS, 1976), but we found no evidence it affects irrigation.
Imp-P5 (Animal toxicity)	n - negl	0	"The tender shoots of *Neptunia oleracea* are cooked as vegetable and pods are eaten fresh as salads in India and Myanmar" (Raju, 1999). No toxicity was observed when *Neptunia oleracea* leaves were administered to rats (Bhoomannavar et al., 2011).
Imp-P6 (Production system weed)	b - mod	0.2	*Neptunia oleracea* is reported to be a weed of rice in India, Cambodia, Laos, and Malaysia (Moody, 1989). Incidental weed in irrigated rice fields in Thailand (IRRI, 1993). Alternate answers for the Monte Carlo simulation are c, then a.
Geographic Potential			Note: Below "p.s." refers to geo-referenced point source (latitude/longitude) data; "occ." refers to occurrence (presence only) data for a region.
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)	n - negl	N/A	No evidence.
Geo-Z5 (Zone 5)	n - negl	N/A	No evidence.
Geo-Z6 (Zone 6)	n - negl	N/A	No evidence.
Geo-Z7 (Zone 7)	n - negl	N/A	No evidence.
Geo-Z8 (Zone 8)	y - high	N/A	Detected in Arkansas and surviving at this location for three years (Peck, 2011; Peck and Serviss, 2011 occur.). The co-author of the paper reporting its initial discovery says it is unlikely to overwinter in this hardiness zone (Serviss, 2011). Given that it has survived in this zone for three years, we are assuming yes, but with high uncertainty.
Geo-Z9 (Zone 9)	y - mod	N/A	Able to grow in USDA Hardiness Zone 9 (Ponds Plants and More, 2011; The Water Garden, 2011)
Geo-Z10 (Zone 10)	y - negl	N/A	Mexico (GBIF, 2011 p.s.), Australia (Hannan-Jones and Csurhes, 2008 p.s.)
Geo-Z11 (Zone 11)	y - negl	N/A	Paraguay, Madagascar (GBIF, 2011 p.s.)
Geo-Z12 (Zone 12)	y - negl	N/A	Brazil, Bolivia (GBIF, 2011 p.s.)

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z13 (Zone 13)	y - negl	N/A	Brazil (GBIF, 2011 p.s.)
Koppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Costa Rica, Columbia (GBIF, 2011 p.s.)
Geo-C2 (Tropical savanna)	y - negl	N/A	Myanmar, Mexico (GBIF, 2011 p.s.)
Geo-C3 (Steppe)	y - negl	N/A	Ecuador, Brazil (GBIF, 2011, p.s.)
Geo-C4 (Desert)	y - negl	N/A	Sudan (GBIF, 2011 p.s.)
Geo-C5 (Mediterranean)	n - mod	N/A	No evidence.
Geo-C6 (Humid subtropical)	y - negl	N/A	Mexico (GBIF, 2011 p.s.)
Geo-C7 (Marine west coast)	y - negl	N/A	Mexico (GBIF, 2011 p.s.)
Geo-C8 (Humid cont. warm sum.)	n - mod	N/A	No evidence.
Geo-C9 (Humid cont. cool sum.)	n - low	N/A	No evidence.
Geo-C10 (Subarctic)	n - negl	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")	y - negl	N/A	Sudan (GBIF, 2011 p.s.)
Geo-R2 (10-20")	y - negl	N/A	Burkina Faso (GBIF, 2011 p.s.)
Geo-R3 (20-30")	y - negl	N/A	Brazil, Madagascar (GBIF, 2011 p.s.)
Geo-R4 (30-40")	y - negl	N/A	Mexico, Cameroon (GBIF, 2011 p.s.)
Geo-R5 (40-50")	y - negl	N/A	Mexico, Benin (GBIF, 2011 p.s.)
Geo-R6 (50-60")	y - negl	N/A	Mexico (GBIF, 2011 p.s.)
Geo-R7 (60-70")	y - negl	N/A	Mexico, Guyana (GBIF, 2011 p.s.)
Geo-R8 (70-80")	y - negl	N/A	Venezuela, Brazil (GBIF, 2011 p.s.)
Geo-R9 (80-90")	y - negl	N/A	Mexico (GBIF, 2011 p.s.)
Geo-R10 (90-100")	y - negl	N/A	Panama (GBIF, 2011 p.s.)
Geo-R11 (100"+)	y - negl	N/A	Columbia, Guatemala (GBIF, 2011 p.s.)
Entry Potential			
Ent-1 (Already here)	y - negl	1	Present in Arkansas (Peck and Serviss, 2011).
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		N/A	

Question ID	Answer - Uncertainty	Score	Notes (and references)
consumption)			
Ent-4i (Other pathway)		N/A	
Ent-5 (Natural dispersal)		N/A	