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Weed Risk Assessment for *Rotala wallichii* (Hook. f.) Koehne (Lythraceae) – Whorly rotala

Rotala wallichii (source: Hodžić, 2014).

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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.

***Rotala wallichii* (Hook. f.) Koehne – Whorly rotala**

Species Information

Family: Lythraceae

Synonyms: *Hydrolythrum wallichii* Hooker fil., *Ammannia wallichii* (Hooker fil.) Kurz., *Ammannia myriophylloides* S.T. Dunn (Kasselmann, 2003).

Common names: Whorly rotala (Dave's Garden, 2015), red pinetree (Clayton et al., 2005; FishandTips.com, 2015).

Botanical description: *Rotala wallichii* is an aquatic, annual herb that grows 5-30 cm high (Kasselmann, 2003; Zhengyi et al., 2015). It grows both emerged and fully submerged. The leaves are whorled and highly variable depending on the growing conditions; submerged leaves are filiform, while emerged leaves are broader and ovate. The shoot tips turn red when exposed to high intensity light in aquariums (Huang et al., 1989; Kasselmann, 2003; Paffrath, 1982; Zhengyi et al., 2015).

Initiation: PPQ received a market access request for *Rotala macrandra*, *R. rotundifolia*, and *R. wallichii* aquatic plants for propagation from the Ministry of Food, Agriculture and Fisheries of the Danish Plant Directorate (MFAF, 2009). These *Rotala* species are not native to the United States (Kasselmann, 2003) and may pose a threat to the United States. Thus, the PERAL Weed Team initiated a weed risk assessment for *R. wallichii*.

Foreign distribution: *Rotala wallichii* is native to Asia, including India, Indonesia, Malaysia, Myanmar, Thailand, Vietnam, Taiwan, and southeastern China (Kasselmann, 2003; Zhengyi et al., 2015). It is cultivated as an ornamental plant in New Zealand (Champion and Clayton, 2000), Canada (Cohen et al., 2007), and Europe (Marek and Bartova, 1998) and has not become naturalized in any of the areas where it has been introduced.

U.S. distribution and status: *Rotala wallichii* was cultivated as an aquarium plant in the United States as early as 1977 (Rataj and Horeman, 1977) and is not known to have escaped or naturalized. This species is not widely available in retail stores, but can be purchased online (AquaticMag, 2015; NaturalAquariums.com, 2009;

Planted Aquariums Central, 2015).
WRA area[1]: Entire United States, including territories.

1. *Rotala wallichii* analysis

Establishment/Spread Potential *Rotala wallichii* is an aquatic plant that grows both emerged and submerged (Paffrath, 1982; Yang, 1987). It is widely cultivated as an aquarium plant (Champion and Clayton, 2000; Cohen et al., 2007; Kasselmann, 2003; Rataj and Horeman, 1977), but has not escaped from cultivation in any area where it has been introduced. Several other species of *Rotala* are considered to be invasive (Holm et al., 1979), but *R. wallichii* does not appear to share many invasive traits with these species. For example, the invasive species *R. rotundifolia* forms dense thickets and disperses by seed (Gettys and Della Torre II, 2014; UF/IFAS, 2015), but *R. wallichii* does not form dense mats and we found very little information about it producing any seed at all. We had very high uncertainty for this risk element.
Risk score = 0 Uncertainty index = 0.35

Impact Potential We found no evidence that *R. wallichii* has any negative impacts in natural environments, urban and suburban settings, or production systems. It does not compete with other plant species or change habitats, and it is not toxic to fish (Kasselmann, 2003). We had an average amount of uncertainty for this risk element.
Risk score = 1 Uncertainty index = 0.14

Geographic Potential Based on three climatic variables, we estimate that about seven percent of the United States is suitable for the establishment of *R. wallichii* (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 *R. wallichii* represents the joint distribution of Plant Hardiness Zones 9-13, areas with 30-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, and humid subtropical.

The area estimated is likely conservative since it only uses three climatic variables. Other environmental variables may further limit the areas in which this species is likely to establish. In its native habitat, *R. wallichii* grows in shallow water, ponds, wet places, paddy fields, and ditches (Huang et al., 1989; Van Steenis, 1961).

Entry Potential We did not assess the entry potential of *R. wallichii* because it is already present in the United States in cultivation (Kasselmann, 2003; Rataj and Horeman, 1977).

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted [definition modified from that for "PRA area"] (IPPC, 2012).

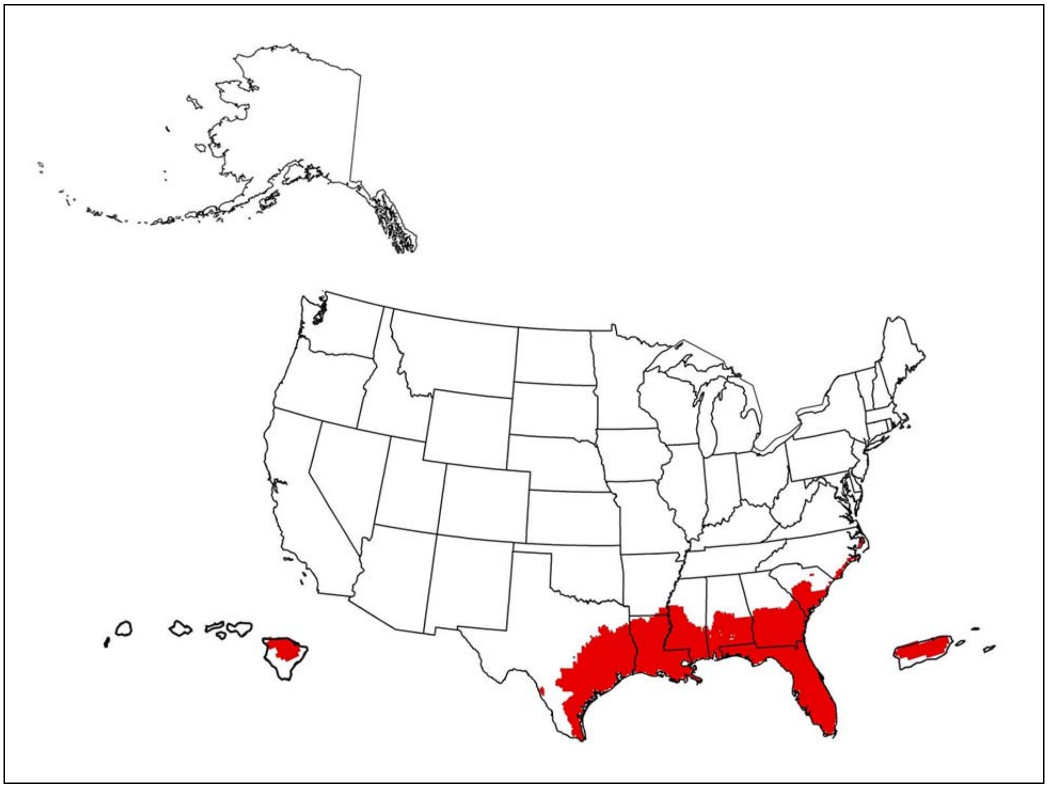

Figure 1. Predicted distribution of *R. wallichii* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 2.8%
P(Minor Invader) = 46.3%
P(Non-Invader) = 50.9%

Risk Result = Low Risk
Secondary Screening = Not Applicable

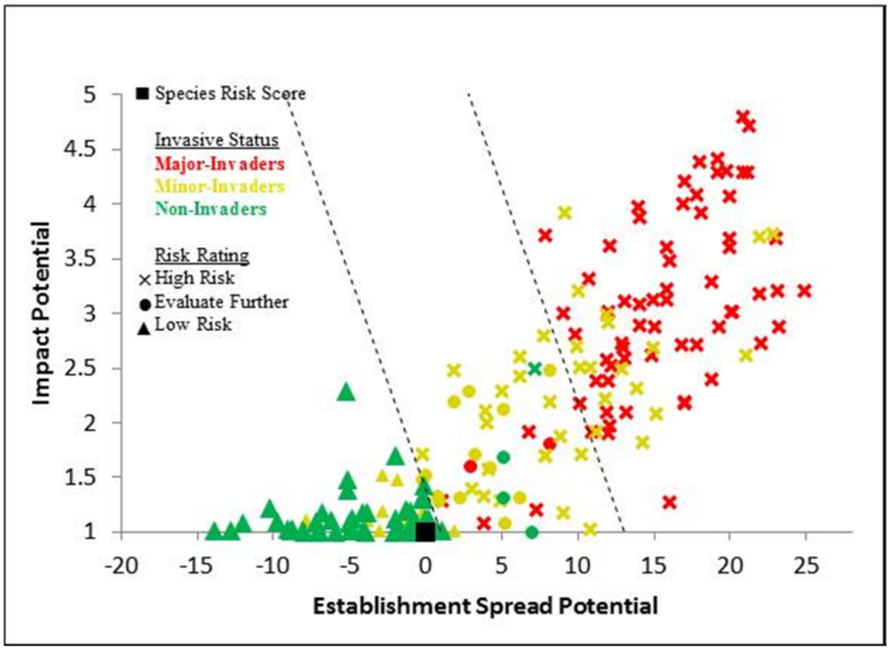

Figure 2. *Rotala wallichii* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

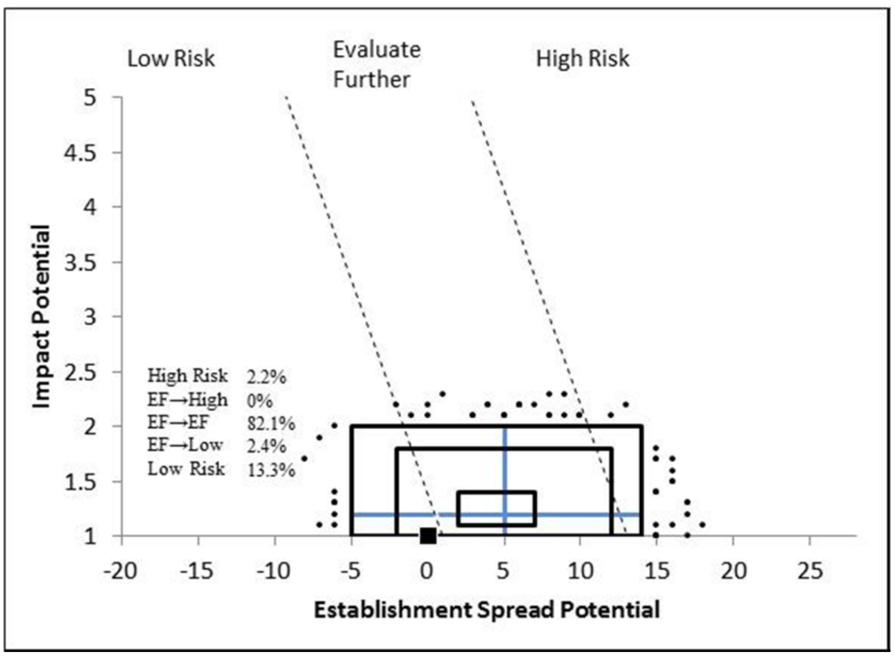

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *R. wallichii*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *R. wallichii* is Low Risk. *Rotala wallichii* has a risk score similar to other low risk species (Fig. 2). Because we found very little information about seed production and dispersal we had very high uncertainty for the establishment/spread risk element, which is demonstrated by the large distribution along that axis in Figure 3. However, our results agree with ratings by other assessors: the National Centre of Aquatic Biodiversity and Biosecurity in New Zealand lists *R. wallichii* as a low-risk, environmentally friendly aquarium/pond plant (Clayton et al., 2005) and Thomas (2010) rated *R. wallichii* as a low risk plant for the United Kingdom.

Rotala wallichii has been cultivated as an aquarium plant in the United States since at least 1977 (Rataj and Horeman, 1977) but has not become naturalized in the United States, nor has it escaped from cultivation anywhere else. It does not appear to aggressively compete with other plants; in aquariums, *R. wallichii* is considered to be a delicate and demanding plant that is very difficult to grow (FlowGrow, 2013; Kasselmann, 2003; Windeløv, 2004), and plant-consuming fish preferentially feed on this plant (Aquatic Plant Central, 2015; Grieshaber, 2013; Kasselmann, 2003). Additionally, *R. wallichii* looks very different from other *Rotala* species (Kasselmann, 2003; Windeløv, 2004) and can be distinguished from its weedy congeners.

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Appendix A. Weed risk assessment for *Rotala wallichii* (Hook. f.) Koehne (Lythraceae). The following information came from the original risk assessment, which is available upon request (full responses and all guidance). We modified the information to fit on the page.

Question ID	**Answer – Uncertainty**	**Score**	**Notes (and references)**
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Status/invasiveness outside its native range)	b - low	-2	*Rotala wallichii* is native to Asia, including India, Indonesia, Malaysia, Myanmar, Thailand, Vietnam, Taiwan, and southeastern China (Kasselmann, 2003; Zhengyi et al., 2015. Listed as "very rare" in Taiwan (Yang, 1987). Occurs in Laos (Newman et al., 2007). Cultivated as an aquarium plant in the United States some time before 1977 (Rataj and Horeman, 1977). Cultivated as an ornamental and not naturalized in New Zealand (Champion and Clayton, 2000). Cultivated as an ornamental plant in Canada (Cohen et al., 2007). Cultivated in glasshouses in the Czech Republic (Marek and Bartova, 1998). *Rotala wallichii* is not listed in PLANTS (NRCS, 2015), GRIN (NGRP, 2015), BONAP (Kartesz, 2015), or EDDMapS (2015). We answered "b" because *R. wallichii* is cultivated as an aquarium plant and we found no evidence of it escaping cultivation where it has been introduced. The alternate answers for the Monte Carlo simulation were “a” and “d.”
ES-2 (Is the species highly domesticated)	n - low	0	We found no evidence of breeding efforts to select desirable cultivars. *Rotala wallichii* is commonly just sold under its species name rather than by any cultivar names (AquaticMag, 2015; Planted Aquariums Central, 2015).
ES-3 (Weedy congeners)	y - low	1	There are over 40 species in the genus *Rotala* (Graham et al., 2011; Joseph and Sivarajan, 1988). Of these, Holm et al. (1979) list *R. indica* as a serious weed in Afghanistan, Japan, Korea, the Philippines, and Taiwan; *R. mexicana* as a principal weed in Japan; *R. rotundifolia* as a principal weed in Taiwan; and *R. uliginosa* as a principal weed in Korea. *Rotala rotundifolia* has naturalized and become problematic in canals in southern Florida (Gettys and Della Torre II, 2014; Graham et al., 2011). *Rotala wallichii* may or may not share traits with other *Rotala* species; *R. wallichii* is an allopatric species (evolving through genetic isolation from other *Rotala* species) that mimics plants in the genus *Hippuris*. It was previously placed in the monotypic genus *Hydrolithrum* (Joseph and Sivarajan, 1988). Thus, we used low uncertainty rather than negligible.
ES-4 (Shade tolerant at some stage of its life cycle)	y - negl	1	In Asia, this species "is much more often found growing submerged and in deeper water than related species" (Aquatic Plant Central, 2015). Grows "…on rocks and logs in full sun or shade" (Clayton et al., 2005). Requires medium to very high light in aquariums (Windeløv, 2004; Clayton et al., 2005), and high light intensity in order to produce red shoot tips (Kasselmann, 2003). Because a very low amount of light is available to fully submerged plants (Riemer, 1993), we answered yes with negligible uncertainty. We believe that this species is very plastic and is able to grow in a wide range of light regimes, from shady to very bright.

Question ID	Answer – Uncertainty	Score	Notes (and references)
ES-5 (Climbing or smothering growth form)	n - negl	0	*Rotala wallichii* is neither a vine nor an herb with a basal rosette; it is an aquatic plant that grows 5-15 cm high (Joseph and Sivarajan, 1988).
ES-6 (Forms dense thickets)	n - high	0	Large populations of *R. wallichii* have been observed (Van Steenis, 1961), but we found no evidence that these populations are particularly dense or crowd out other species. Thus, we answered no, but used high uncertainty.
ES-7 (Aquatic)	y - negl	1	*Rotala wallichii* is an aquatic plant (Joseph and Sivarajan, 1988) that grows both submerged (Clayton et al., 2005) and emerged (Paffrath, 1982; Yang, 1987).
ES-8 (Grass)	n - negl	0	*Rotala wallichii* is not a grass; it is in the family Lythraceae (Huang et al., 1989; Paffrath, 1982).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	*Rotala wallichii* is a herbaceous plant (Huang et al., 1989) and the family Lythraceae is not known to contain nitrogen-fixing species (Martin and Dowd, 1990).
ES-10 (Does it produce viable seeds or spores)	? - max	0	Zhengyi et al. (2015) describe the seeds of *R. wallichii*, but Kasselmann (2003) says "fruit not seen." We did not find any information about seed reproduction or propagation Thus, we answered unknown.
ES-11 (Self-compatible or apomictic)	? - max	0	The genus *Rotala* contains species with cleistogamous flowers (which are non-opening, self-pollinating flowers) (Knuth and Müller, 1906) but we only found vague information about pollination in *R. wallichii* from an aquarium website: "Reproduction is done by flowers in the wild (male and female plants)" (FishandTips.com, 2015). Thus, we answered unknown.
ES-12 (Requires special pollinators)	? - max		Unknown. The flowers of *R. wallichii* possess nectar scales (Joseph and Sivarajan, 1988) but we found no indication that these scales attract pollinators.
ES-13 (Minimum generation time)	b - low	1	The species is an "annual herb" (Huang et al., 1989). The family Lythraceae mainly contains annual species (Bailey and Bailey, 1976). However, this species is called a perennial in other sources (Clayton et al., 2005; Zhengyi et al., 2015). In China, *R. wallichii* flowers and fruits in autumn and winter (Zhengyi et al., 2015). Based on this evidence, we answered "b" with low uncertainty. The alternate answers for the Monte Carlo simulation were "c" and "a."
ES-14 (Prolific reproduction)	n - high	-1	*Rotala wallichii* forms inflorescences but "fruit not seen" (Kasselmann, 2003). "*Ammannia*, *Nesaea* and *Rotala* have...c. 200 or more minute brown seeds per capsule" (Graham et al., 2011). Because we found very little information about this plant producing seeds in general, we answered no, but used high uncertainty.
ES-15 (Propagules likely to be dispersed unintentionally by people)	? - max	0	*Rotala wallichii* has been incorrectly labeled as mayaca in the aquarium trade (Rataj and Horeman, 1977), which could contribute to unintentional dispersal. However, because we had no direct evidence of this, we answered unknown.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	? - max	0	We found no evidence that *R. wallichii* has been found as a contaminant, but aquatic plants in general are often unintentionally dispersed through the aquarium trade (Keller and Lodge, 2007; Maki and Galatowitsch, 2004). Thus, we answered unknown.

Question ID	Answer – Uncertainty	Score	Notes (and references)
ES-17 (Number of natural dispersal vectors)	1	-2	Fruit and seed descriptions used to answer ES-17a-e: "Capsules globose, ca. 1 mm in diam., 2-valved. Seeds ca. 0.7 mm" (Zhengyi et al., 2015). "*Ammannia*, *Nesaea* and *Rotala* have...c. 200 or more minute brown seeds per capsule" (Graham et al., 2011) Members of the genus *Rotala* have obovoid to semi-ovoid (boat-shaped) seeds that are brown, gold, or red, and 0.3-1 x 0.2-0.4 mm in size that contain aerenchymatous float tissue (Graham et al., 2011).
ES-17a (Wind dispersal)	n - mod		We found no evidence that *R. wallichii* disperses in this manner. The seeds have no adaptations for wind dispersal.
ES-17b (Water dispersal)	y - negl		*Rotala* species have boat-shaped seeds that are buoyant due to their aerenchymatous float tissue (Graham et al., 2011). Additionally, the stems of *R. wallichii* break easily (FishandTips.com, 2015), which likely contributes to propagule dispersal in water. We answered yes with negligible uncertainty based on these adaptations and because *R. wallichii* is an aquatic plant.
ES-17c (Bird dispersal)	? - max		Waterfowl disperse many aquatic plant species (Brochet et al., 2009; Figuerola and Green, 2002). Other members of the genus *Rotala* (*R. ramosior* and *R. repens*) have exotestal seed trichomes that appear when seeds are wetted. The seeds then become viscid and can attach to animals that can disperse the seeds (Graham et al., 2011; Mabberley, 2008). However, it is unclear if this occurs in *R. wallichii*, so we answered unknown.
ES-17d (Animal external dispersal)	? - max		Other *Rotala* species (e.g., *R. ramosior* and *R. repens*) have seed trichomes that appear when seeds are wetted. The seeds then become viscid and can attach to animal dispersal agents (Graham et al., 2011; Mabberley, 2008). However, it is unclear if this occurs in *R. wallichii*. Thus, we answered unknown.
ES-17e (Animal internal dispersal)	n - high		We found no evidence that *R. wallichii* disperses in this manner. We used high uncertainty because very little information was available on *R. wallichii* seed production and dispersal in general.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	n - high	-1	We found no evidence that *R. wallichii* has a persistent seed bank. We used high uncertainty because we found very little information about seeds in general for this species.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - high	1	Propagated by lateral shoot cuttings (Kasselmann, 2003). "[S]uitable for small aquariums because it is easy to prune if it grows too large" (Windeløv, 2004). Shoot cuttings quickly re-root if planted in substrate (FlowGrow, 2013). The stems of *R. wallichii* break easily (FishandTips.com, 2015). Mechanical control of the related species *R. rotundifolia* can disperse vegetative propagules (Gettys and Della Torre II, 2014). Based on this evidence, we answered yes, but used high uncertainty.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - high	0	We found no evidence that *R. wallichii* has been targeted for control by chemical herbicides. However, *Rotala indica* var. *uliginosa* has evolved resistance to group B/2 herbicides used in rice fields in Japan (Heap, 2015). The herbicide 2,4-D is effective at controlling *R. indica* (Watanabe, 2011) and triclopyr and 2,4-D are effective at controlling *R. rotundifolia* (Gettys and Della Torre II, 2014). Based on this information, we answered no, but used high uncertainty.

Question ID	Answer – Uncertainty	Score	Notes (and references)
ES-21 (Number of cold hardiness zones suitable for its survival)	5	0	
ES-22 (Number of climate types suitable for its survival)	3	0	
ES-23 (Number of precipitation bands suitable for its survival)	8	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - mod	0	We found no evidence that *R. wallichii* is allelopathic.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that *R. wallichii* is a parasitic plant. The family Lythraceae is not known to contain parasitic plants (Heide-Jørgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	n - mod	0	We found no evidence that *R. wallichii* has any impacts, or has even become naturalized, in natural systems outside of its native range. Thus, we answered no for questions Imp-N1 through Imp-N5. We used moderate uncertainty for these questions because *R. wallichii* has been cultivated for less than 75 years in the United States.
Imp-N2 (Change community structure)	n - mod	0	See evidence for Imp-N1.
Imp-N3 (Change community composition)	n - mod	0	See evidence for Imp-N1.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	n - mod	0	See evidence for Imp-N1.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	n - mod	0	See evidence for Imp-N1.
Imp-N6 (Weed status in natural systems)	a - low	0	The National Centre of Aquatic Biodiversity and Biosecurity in New Zealand lists *R. wallichii* as a low-risk, environmentally friendly aquarium/pond plant (Clayton et al., 2005). Champion and Clayton (2000) list *R. wallichii* as not being recorded as a weed overseas from New Zealand. Randall (2007) includes *R. wallichii* in his list of non-native species in Australia but does not list it as being a weed. Rated as a low risk plant for the United Kingdom (Thomas, 2010). Based on this evidence, we answered "a" with low uncertainty. The alternate answers for the Monte Carlo simulation were both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	n - mod	0	We found no evidence that *R. wallichii* has this impact.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	We found no evidence that *R. wallichii* has this impact.

Question ID	Answer – Uncertainty	Score	Notes (and references)
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	n - low	0	We found no evidence that *R. wallichii* has this impact. This *Rotala* species is a "delicate…demanding and sensitive aquarium plant" (Kasselmann, 2003), and a "demanding plant" (Windeløv, 2004) that is difficult to grow in aquariums (FlowGrow, 2013). Thus, it seems unlikely to aggressively compete with other aquarium plants. We used low uncertainty.
Imp-A4 (Weed status in anthropogenic systems)	a - low	0	Not listed by Randall (2012; 2015). Because we found no evidence of this plant having any impacts or even becoming naturalized in urban and suburban settings, we answered "a" with low uncertainty. The alternate answers for the Monte Carlo simulation were both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - mod	0	We found no evidence that *R. wallichii* occurs in production systems or has this impact.
Imp-P2 (Lowers commodity value)	n - mod	0	We found no evidence that *R. wallichii* occurs in production systems or has this impact.
Imp-P3 (Is it likely to impact trade)	n - mod	0	We found no evidence that *R. wallichii* may impact trade. *Rotala indica* and *R. rotundifolia* are listed as harmful organisms by other countries but *R. wallichii* is not (APHIS, 2015).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	We found no evidence that *R. wallichii* has this impact.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	We found no evidence that *R. wallichii* is toxic. "Plant-consuming fish love to feed on the delicate leaves" (Kasselmann, 2003). Angel fish enjoy *R. wallichii* and may aggressively feed on this plant in aquariums (Grieshaber, 2013). "[I]t is a frequent target of fish and invertebrates inclined to browse on aquatic vegetation" (Aquatic Plant Central, 2015). The genus *Rotala* is not listed *Toxic Plants of North America* (Burrows and Tyrl, 2001).
Imp-P6 (Weed status in production systems)	a - mod	0	We found no evidence that *R. wallichii* is a weed in production systems. It occurs in paddy fields in Taiwan (Huang et al., 1989) but we found no indication of impacts. Moody (1989) lists 11 *Rotala* species as reported weeds of rice in south and southeast Asia, but *R. wallichii* is not listed as one of them. Thus, we answered "a," but used moderate uncertainty because other *Rotala* species occur in rice systems. The alternate answers for the Monte Carlo simulation were both "b."
GEOGRAPHIC POTENTIAL			Note: Below "p.s." refers to geo-referenced point source (latitude/longitude) data; "occur" refers to occurrence (presence only) data for a region.
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that *Rotala wallichii* occurs in this plant hardiness zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that *Rotala wallichii* occurs in this plant hardiness zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that *Rotala wallichii* occurs in this plant hardiness zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence that *Rotala wallichii* occurs in this plant hardiness zone.

Question ID	Answer – Uncertainty	Score	Notes (and references)
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence that *Rotala wallichii* occurs in this plant hardiness zone.
Geo-Z6 (Zone 6)	n - negl	N/A	We found no evidence that *Rotala wallichii* occurs in this plant hardiness zone.
Geo-Z7 (Zone 7)	n - low	N/A	We found no evidence that *Rotala wallichii* occurs in this plant hardiness zone.
Geo-Z8 (Zone 8)	n - high	N/A	We found no evidence that *Rotala wallichii* occurs in this plant hardiness zone.
Geo-Z9 (Zone 9)	y - low	N/A	Northeast Kwantung (Guangdong), China (GBIF, 2015, occur.).
Geo-Z10 (Zone 10)	y - low	N/A	Only occurs in north and northeastern India (Joseph and Sivarajan, 1989, occur.). Guangdong, China (Zhengyi et al., 2015, occur.).
Geo-Z11 (Zone 11)	y - negl	N/A	Laos (GBIF, 2015, p.s.) and Myanmar (Zhengyi et al., 2015, occur.).
Geo-Z12 (Zone 12)	y - negl	N/A	Thailand and Indonesia (Zhengyi et al., 2015, occur.).
Geo-Z13 (Zone 13)	y - negl	N/A	Taiwan (GBIF, 2015, p.s.), Indonesia, and Malaysia (Zhengyi et al., 2015, occur.). Recommended growing temperature in aquariums is 18-28 °C (Clayton et al., 2005; Windeløv, 2004). Optimum temperature range in aquaria is 24-28 °C (Kasselmann, 2003). 22-28 °C (Paffrath, 1982).
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Laos (GBIF, 2015, p.s.), Indonesia, and Malaysia (Zhengyi et al., 2015, occur.).
Geo-C2 (Tropical savanna)	y - negl	N/A	Taiwan (GBIF, 2015, p.s.), Thailand, Vietnam, and Myanmar (Zhengyi et al., 2015, occur.).
Geo-C3 (Steppe)	n - mod	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
Geo-C4 (Desert)	n - negl	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
Geo-C5 (Mediterranean)	n - mod	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
Geo-C6 (Humid subtropical)	y - low	N/A	Guangdong, China; Vietnam (Zhengyi et al., 2015, occur.); and northeastern India (Joseph and Sivarajan, 1989, occur.).
Geo-C7 (Marine west coast)	n - mod	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
Geo-C8 (Humid cont. warm sum.)	n - mod	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
Geo-C9 (Humid cont. cool sum.)	n - low	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that *R. wallichii* occurs in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - high	N/A	We found no evidence that *R. wallichii* occurs in this precipitation band.
Geo-R2 (10-20 inches; 25-51 cm)	n - high	N/A	We found no evidence that *R. wallichii* occurs in this precipitation band.
Geo-R3 (20-30 inches; 51-76 cm)	n - high	N/A	We found no evidence that *R. wallichii* occurs in this precipitation band.

Question ID	Answer – Uncertainty	Score	Notes (and references)
Geo-R4 (30-40 inches; 76-102 cm)	y - high	N/A	North and northeastern India (Joseph and Sivarajan, 1989, occur.).
Geo-R5 (40-50 inches; 102-127 cm)	y - mod	N/A	North and northeastern India (Joseph and Sivarajan, 1989, occur.).
Geo-R6 (50-60 inches; 127-152 cm)	y - low	N/A	North and northeastern India (Joseph and Sivarajan, 1989, occur.).
Geo-R7 (60-70 inches; 152-178 cm)	y - low	N/A	North and northeastern India (Joseph and Sivarajan, 1989, occur.).
Geo-R8 (70-80 inches; 178-203 cm)	y - low	N/A	Thailand and Myanmar (Zhengyi et al., 2015, occur.).
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Taiwan (GBIF, 2015, p.s.).
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Thailand and Myanmar (Zhengyi et al., 2015, occur.).
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	Laos (GBIF, 2015, p.s.), Indonesia, and Myanmar (Zhengyi et al., 2015, occur.).
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	Cultivated as an aquarium plant in the United States since at least 1977 (Rataj and Horeman, 1977). Not widely available from local stores in the United States, but can be purchased online (AquaticMag, 2015; NaturalAquariums.com, 2009; Planted Aquariums Central, 2015).
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	*Rotala wallichii* has been proposed for importation into the United States from Denmark (MFAF, 2009).
Ent-3 (Human value & cultivation/trade status)	-	N/A	Cultivated as an ornamental plant in Canada (Cohen et al., 2007).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	-	N/A	Cultivated as an ornamental plant in Canada (Cohen et al., 2007).
Ent-4b (Contaminant of plant propagative material (except seeds))	-	N/A	
Ent-4c (Contaminant of seeds for planting)	-	N/A	
Ent-4d (Contaminant of ballast water)	-	N/A	
Ent-4e (Contaminant of aquarium plants or other aquarium products)	-	N/A	
Ent-4f (Contaminant of landscape products)	-	N/A	
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	-	N/A	

Question ID	Answer – Uncertainty	Score	Notes (and references)
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	-	N/A	
Ent-4i (Contaminant of some other pathway)	-	N/A	
Ent-5 (Likely to enter through natural dispersal)	-	N/A	