United States Department of Agriculture

Weed Risk Assessment for *Anubias barteri* Schott (Araceae)

United States Department of Agriculture

Animal and Plant Health Inspection Service

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Version 1

Anubias barteri var. *barteri* (source: TROPICA, 2013).

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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.

	***Anubias barteri* Schott**
Species	Family: Araceae
Information	Synonyms: *Anubias lanceolata* N. E. Br.; *Anubias nana* (NGRP, 2013). *Anubias barteri* var. *angustifolia* used to be sold in the aquarium trade under the name of *A. afzelii* (TROPICA, 2013). *Anubias afzelii* is a different and valid species (Crusio, 1979).
	Initiation: PPQ received a market access request for *Anubias barteri* for aquatic plant propagation from the Ministry of Food, Agriculture and Fisheries, the Danish Plant Directorate (MFAF, 2009). Because this species is not native to the United States (NGRP, 2013) and may pose a phytosanitary risk, the PERAL Weed Team initiated this assessment.
	Foreign distribution: This species is native to Cameroon, the Republic of the Congo, Cote D'Ivoire, Equatorial Guinea, Gabon, Guinea, Liberia and Nigeria (NGRP, 2013). It is the most widely distributed species in the genus, reaching from Guinea to the Congo (Crusio, 1979).
	U.S. distribution and status: This species is cultivated (Anonymous, 2011) and commercially grown (Lehman et al., 2000) in the United States. It is listed for sale on the internet by at least one major distributor (Petco, 2013). *Anubias barteri* was probably introduced for cultivation in the United States between 1930 (Bailey and Bailey, 1930) and 1959 (Gordon and Gantz, 2011b). We found no evidence that this species has escaped or naturalized in the United States (e.g., Gordon and Gantz, 2011b).
	WRA area[1]: Entire United States, including territories.

[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).

1. *Anubias barteri* analysis

Establishment/Spread Potential

Anubias barteri is a perennial aquatic herb with morphologically variable leaves that emerge from a creeping rhizome (Crusio, 1979). It grows in moist and shady sites on the edge of watercourses, in rocks, or on old wood; emersed or temporarily submerged (Crusio, 1979). Despite this species' popularity in the aquarium trade, very little is known about its ecology, including aspects related to its reproductive and dispersal biology. It has been in cultivation at least 40 years (Martin and Coetzee, 2011) and is not known to have escaped. We had high uncertainty.
Risk score = -9 Uncertainty index = 0.29

Impact Potential

We found no evidence this species causes any kind of impact. This is not surprising given that we found no evidence that it has naturalized beyond its native range. We had average uncertainty with this risk element.
Risk score = 1 Uncertainty index = 0.14

Geographic Potential

Based on three climatic variables, we estimate that about 0.05 percent of the United States is suitable for the establishment of *A. barteri* (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 *A. barteri* represents the joint distribution of Plant Hardiness Zones 11-13, areas with 50-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest and tropical savanna. They can only be grown successfully when kept in a very humid soil and atmosphere that is preferably at or above 22 °F (Crusio, 1979). We suspect that this plant could survive in Plant Hardiness Zone 10 and in steppe and subtropical forests but we found no evidence of that. Regardless of this scenario, the percent of the United States that would be suitable for establishment would still be very small.

The area estimated likely represents a conservative estimate as it only uses three climatic variables. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish. *Anubias* species grow in forests, in wet shady places, mostly along the edges of watercourses, and sometimes they can grow submerged (Crusio, 1979).

Entry Potential

We did not assess the entry potential of *A. barteri* because it is already present in and grown in the United States (Anonymous, 2011; Lehman et al., 2000).

Figure 1. Predicted distribution of *Anubias barteri* 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) = 0.3%
P(Minor Invader) = 10.%
P(Non-Invader) = 89.6%

Risk Result = Low Risk

Secondary Screening = Not Applicable

Figure 2. *Anubias barteri* 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.

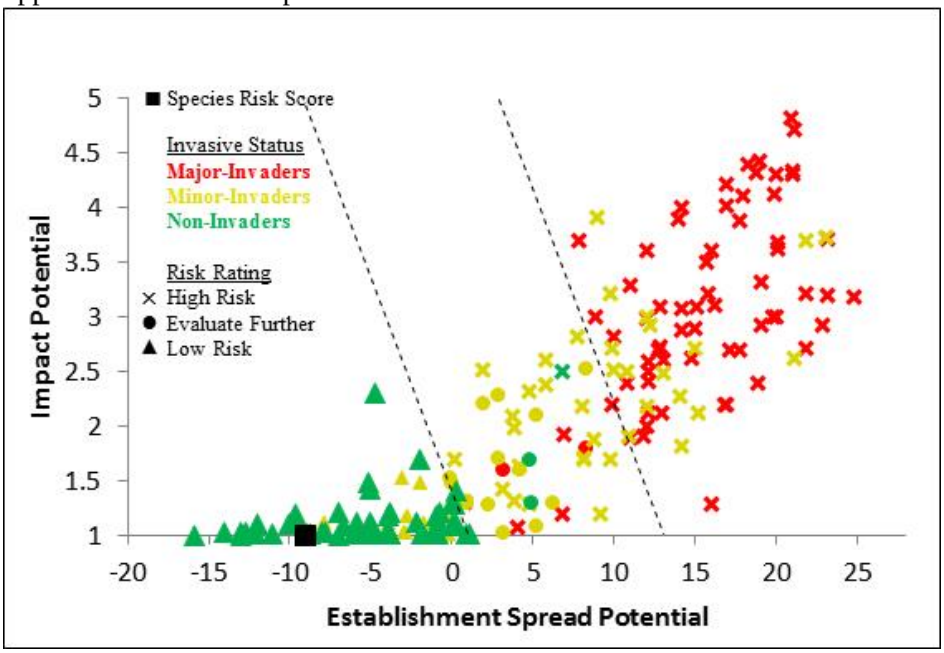
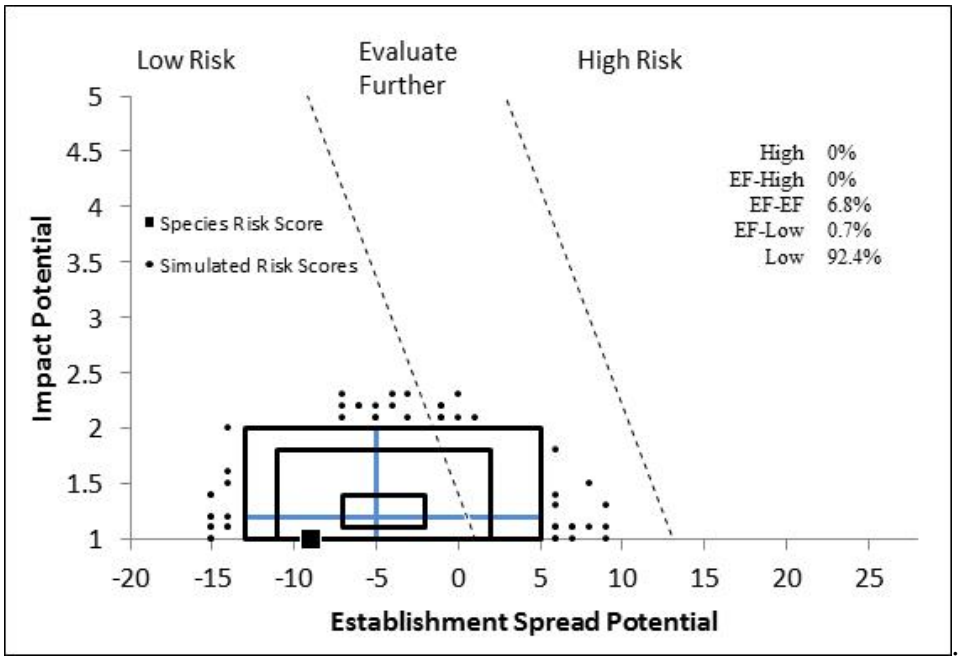


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Anubias barteri*[a].



[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 *Anubias barteri* is Low Risk (Fig. 2). Uncertainty was average for impact potential, but high for establishment/spread potential. Based on the results of the uncertainty simulation (Fig. 3), though, we are confident in the result of low risk. *Anubias barteri* has been evaluated with two other weed risk assessment systems for the United States. Analysis with the Australian weed risk assessment model led to a conclusion of Evaluate Further, but that model automatically assigns five points to all aquatic species, making it difficult for them to obtain a result of low risk (Gordon and Gantz, 2011b). Analysis with a weed risk assessment model designed specifically for aquatic plants resulted in a conclusion of low risk (Gordon and Gantz, 2011a). Overall, based on these results, the relatively slow growth rate of *Anubias* plants (Tangpong et al., 2009; Thomas, 2010), and the limited U.S. area suitable for establishment, we are confident that *Anubias barteri* poses a low risk potential for the United States.

4. Literature Cited

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Appendix A. Weed risk assessment for *Anubias barteri* Schott (Araceae). 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	This species is native to western, tropical Africa (Crusio, 1979). Introduced to Australia with no evidence of escape (Randall, 2007). Imported into one or more European countries (Brunel, 2009). Present in South Africa for at least 40 years (Martin and Coetzee, 2011). Cultivated and commercially grown with no evidence of escape in New Zealand (Champion and Clayton, 2000) and China (Xu et al., 2012). Because this species is widely cultivated, we answered "b" with low uncertainty. Alternate answers for the Monte Carlo simulation are both "a."
ES-2 (Is the species highly domesticated)	n - low	0	This species is cultivated as an ornamental aquatic plant (Brunel, 2009; Kanchanapoom et al., 2012; Xu et al., 2012). Shoot-tip culture is used to micropropagate plants (Kanchanapoom et al., 2012). Several cultivars have been developed (Oyedeji and Abowei, 2012). We found no evidence of any breeding that would reduce weed potential.
ES-3 (Weedy congeners)	n - low	0	We found no evidence. The genus contains about eight species (Crusio, 1979; Mabberley, 2008). None are listed as weedy in the Global Compendium of Weeds (Randall, 2012). The genus has been introduced to Malesia with no evidence of escape (Boyce and Yeng, 2012).
ES-4 (Shade tolerant at some stage of its life cycle)	y - negl	1	In general, *Anubias* species, including *A. barteri* grow in wet, shady places of forests, mostly along water courses (Crusio, 1979).
ES-5 (Climbing or smothering growth form)	n - negl	0	Not a vine or an herb with a basal rosette. Species is an herb with leaves emerging from short rhizomes (Bailey and Bailey, 1976; Crusio, 1979).
ES-6 (Forms dense thickets)	n - mod	0	We found no evidence.
ES-7 (Aquatic)	y - negl	1	This species grows on the edge of watercourses, in rocks, or on old wood; emersed or temporarily submerged (Crusio, 1979). Species in the genus *Anubias* are classified as helophytes, which are species with semi-cryptic meristems and growing in saturated soil or in water with leaves and flowers above the water surface (Boyce and Yeng, 2012). Species is aquatic and used in aquaria (TROPICA, 2013).
ES-8 (Grass)	n - negl	0	Not a grass. Species is in the Araceae family (NGRP, 2013).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence. No member of the Araceae family is known to fix nitrogen (Martin and Dowd, 1990). Furthermore, this isn't a woody plant
ES-10 (Does it produce viable seeds or spores)	? - max	0	Unknown. It produces flowers and fruit (Crusio, 1979), but we found no information on sexual reproduction or seed viability. In aquaculture, it is propagated by rhizome cuttings (APC, 2003) and tissue culture (Kanchanapoom et al., 2012).
ES-11 (Self-compatible or apomictic)	? - max	0	Unknown.
ES-12 (Requires special pollinators)	? - max		Unknown.
ES-13 (Minimum generation	c - high	0	*Anubias* species are slow growing (APC, 2003; Tangpong et al.,

Question ID	Answer - Uncertainty	Score	Notes (and references)
time)			2009; Thomas, 2010) herbaceous perennials (Crusio, 1979). Thus it is unlikely that their minimum generation time is a year or less, for either sexual or vegetative reproduction (through rhizomes). We answered "c" with high uncertainty. Alternate answers for the Monte Carlo simulation were "d" and “b”."
ES-14 (Prolific reproduction)	n - mod	-1	Although we have no information on seed production or sexual reproduction, this species is unlikely to reproduce prolifically for a few reasons. First, aquatic plants in general undergo sporadic sexual reproduction (Les and Philbrick, 1993). Second, examination of a photograph of an *A. barteri* inflorescence (Crusio, 1979) shows 1-2 dozen female flowers (although we don't know how many seeds each may produce). Finally, since shoot-tip culture is used to micropropagate plants (Kanchanapoom et al., 2012) neither sexual nor vegetative reproduction seems likely to be very fast.
ES-15 (Propagules likely to be dispersed unintentionally by people)	n - high	-1	We found no evidence that this species or any other *Anubias* species is dispersed unintentionally. However, because many aquatic plant invasions are due to dumping of aquarium material, we answered with high uncertainty.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - mod	-1	We found no evidence (e.g., PestID, 2013).
ES-17 (Number of natural dispersal vectors)	1	-2	Fruit and seed description for question ES-17a to ES-17e: Berries enclosed by the spathe, each with many small seeds (Crusio, 1979). Seeds are 0.5 to 1 mm long, and 0.4 to 0.8 mm broad (Crusio, 1979).
ES-17a (Wind dispersal)	n - low		We found no evidence. Fruit, which are berries, possess no adaptations for wind dispersal.
ES-17b (Water dispersal)	y - high		We found no evidence that this species or any *Anubias* species is dispersed by water. However, because these species live in or on the edge of aquatic environments it seems reasonable they would be dispersed by water. Consequently, we answered yes but with high uncertainty.
ES-17c (Bird dispersal)	? - max		We found no evidence that this species or any *Anubias* species is dispersed by birds. Because the fruit is a berry, however, they may be consumed and dispersed by birds.
ES-17d (Animal external dispersal)	n - mod		We found no evidence. From descriptions, the fruit does not appear to have any mechanisms to facilitate animal attachment.
ES-17e (Animal internal dispersal)	? - max		We found no evidence that this species or any *Anubias* species is dispersed by other animals. Because berries may be attractive to other animals besides birds, however, we answered unknown.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	Unknown.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	n - low	-1	Plants with a prostrate, creeping and rooting rhizome that is 0.2 to 1 cm thick (Crusio, 1979). Can be propagated via rhizome cuttings (APC, 2003), but we found no evidence that it tolerates mutilation. Because this species grows slowly (APC, 2003) and because tissue culture appears to be the best mechanism for horticultural propagation (Kanchanapoom et al., 2012), we answered no with low uncertainty. This species is widely cultivated (Brunel, 2009; Kanchanapoom et al., 2012; Xu et al.,

Question ID	Answer - Uncertainty	Score	Notes (and references)
			2012).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence. Not listed by Heap (2013). As this species is not considered a weed, it is highly unlikely to have developed herbicide resistance through selection.
ES-21 (Number of cold hardiness zones suitable for its survival)	3	-1	
ES-22 (Number of climate types suitable for its survival)	2	-2	
ES-23 (Number of precipitation bands suitable for its survival)	6	0	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	We found no evidence. Aquatic species seem unlikely to develop allelopathy.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence. The Araceae is not known to contain parasitic plants (Heide-Jorgensen, 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.
Imp-N2 (Change community structure)	n - mod	0	We found no evidence.
Imp-N3 (Change community composition)	n - mod	0	We found no evidence.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	n - mod	0	We found no evidence.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	n - mod	0	We found no evidence.
Imp-N6 (Weed status in natural systems)	a - low	0	We found no evidence it is a considered a weed. A New Zealand risk assessment of this species did not find any evidence that it is considered a weed overseas (Champion and Clayton, 2000). 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.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	We found no evidence.
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	n - mod	0	We found no evidence.
Imp-A4 (Weed status in anthropogenic systems)	a - low	0	We found no evidence it is a considered a weed. A New Zealand risk assessment of this species did not find any evidence it is considered a weed overseas (Champion and Clayton, 2000). Alternate answers for the Monte Carlo simulation were both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P1 (Reduces crop/product yield)	n - mod	0	We found no evidence.
Imp-P2 (Lowers commodity value)	n - mod	0	We found no evidence.
Imp-P3 (Is it likely to impact trade)	n - low	0	*Anubias* species are prohibited from introduction into South Africa under the Agricultural Pests Acts in a category indicating that they are in the country and must not be imported (although they have been in South Africa for 40 years) (Martin and Coetzee, 2011). Because we didn't find any evidence of *Anubias* species contaminating a commodity in trade, we answered no. Furthermore, because *A. barteri* is likely to have low reproductive potential, it is less likely for it to contaminate a trade pathway. Consequently, we rated the uncertainty as low.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	We found no evidence.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - mod	0	We found no evidence.
Imp-P6 (Weed status in production systems)	a - mod	0	Prohibited from entry into South Africa under the Agricultural Pests Acts (Martin and Coetzee, 2011), which indicates that it may be a weed. A New Zealand risk assessment of this species found no evidence it is considered a weed overseas (Champion and Clayton, 2000). Consequently, we answered "a" but with moderate uncertainty. Alternate answers for the Monte Carlo simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, all evidence below is based on geo-referenced point occurrences from the Global Biodiversity Information Facility (GBIF, 2013). Additionally, occurrences obtained from Crusio (1979) represent point occurrences on a map.
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence.
Geo-Z6 (Zone 6)	n - negl	N/A	We found no evidence.
Geo-Z7 (Zone 7)	n - negl	N/A	We found no evidence.
Geo-Z8 (Zone 8)	n - negl	N/A	We found no evidence.
Geo-Z9 (Zone 9)	n - negl	N/A	We found no evidence.
Geo-Z10 (Zone 10)	n - high	N/A	We found no evidence. This species may be able to survive occasional frosts associated with this zone.
Geo-Z11 (Zone 11)	y - negl	N/A	A few points in Liberia and Cameroon. Cote d'Ivoire (Crusio, 1979).
Geo-Z12 (Zone 12)	y - negl	N/A	Gabon and Cameroon.
Geo-Z13 (Zone 13)	y - negl	N/A	Gabon, Cameroon, Liberia, and Nigeria.
Köppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Cameroon, Equatorial Guinea, and Liberia.
Geo-C2 (Tropical savanna)	y - negl	N/A	Gabon, Cameroon, and Liberia. Cote d'Ivoire (Crusio, 1979)

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C3 (Steppe)	n - high	N/A	We found no evidence, but may be able to survive in forested riparian areas.
Geo-C4 (Desert)	n - mod	N/A	We found no evidence.
Geo-C5 (Mediterranean)	n - mod	N/A	We found no evidence.
Geo-C6 (Humid subtropical)	n - high	N/A	We found no evidence.
Geo-C7 (Marine west coast)	n - low	N/A	We found no evidence.
Geo-C8 (Humid cont. warm sum.)	n - negl	N/A	We found no evidence.
Geo-C9 (Humid cont. cool sum.)	n - negl	N/A	We found no evidence.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - negl	N/A	We found no evidence.
Geo-R2 (10-20 inches; 25-51 cm)	n - negl	N/A	We found no evidence.
Geo-R3 (20-30 inches; 51-76 cm)	n - low	N/A	We found no evidence.
Geo-R4 (30-40 inches; 76-102 cm)	n - high	N/A	We found no evidence.
Geo-R5 (40-50 inches; 102-127 cm)	n - high	N/A	We found no evidence.
Geo-R6 (50-60 inches; 127-152 cm)	y - low	N/A	Cameroon. Cote d'Ivoire (Crusio, 1979)
Geo-R7 (60-70 inches; 152-178 cm)	y - low	N/A	Cameroon and Liberia.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Cameroon and Gabon.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Cameroon and Gabon.
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Cameroon and Gabon.
Geo-R11 (100+ inches; 254+ cm))	y - negl	N/A	Gabon and Equatorial Guinea.
Entry Potential			
Ent-1 (Plant already here)	y - negl	1	Species is commercially cultivated in Florida (Lehman et al., 2000).
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	-	N/A	
Ent-4b (Contaminant of plant propagative material (except seeds))	-	N/A	
Ent-4c (Contaminant of seeds	-	N/A	

Question ID	Answer - Uncertainty	Score	Notes (and references)
for planting)			
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	
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	