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Weed Risk Assessment for *Achyranthes japonica* (Miq.) Nakai – Japanese chaff flower

Top: dried stalks and flowers. Right: patch of *Achyranthes japonica*. Center: *A. japonica* flower. Bottom left: seeds stuck on sweater (source: Chris Evans, Illinois Wildlife Action Plan, Bugwood.org).

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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.

***Achyranthes japonica* (Miq.) Nakai – Japanese chaff flower**

Species Information

Family: Amaranthaceae

Synonyms: *Achyranthes bidentata* var. *japonica* Miq. (basionym) (eFloras, 2013).

Common names: Japanese chaff flower (Evans, 2010)

Botanical description: *Achyranthes japonica* is a perennial herbaceous plant growing up to two meters tall; it is found in bottomland forests, and along annually flooded riverbanks, field edges, and ditches (Evans, 2010; Gleason and Cronquist, 1991).

Initiation: Al Tasker, USDA-APHIS-PPQ, forwarded an email from Charles Bryson, USDA Agricultural Research Service, advising that *Achyranthes japonica* was expanding its range into extreme southeastern Missouri along the Mississippi River and asking if it could become an agricultural weed in row crops, especially rice and irrigated soybean, and cotton (Bryson, 2011).

Foreign distribution: *Achyranthes japonica* is native to eastern Asia and is distributed throughout Japan and both North and South Korea (WHO, 1998). It also occurs in Australia (Randall, 2007), Taiwan (GBIF, 2011), and the Yunnan Province of China (Zhou and Wang, 2005).

U.S. distribution and status: This species was first reported in Kentucky in the early 1980s and quickly spread along the Ohio River and its tributaries. It is currently established in at least 49 counties in nine states (Alabama, Georgia, Illinois, Indiana, Kentucky, Missouri, Ohio, Tennessee, and West Virginia), mostly along the river (Bryson, 2011; Evans, 2010; UGA-CISEH, 2011). *Achyranthes japonica* is not currently regulated by any state in which it is established (NPB, 2014), but it is under local control in Illinois (funded by the state), listed as an invasive exotic plant in Indiana, considered a severe threat in Kentucky, listed as a Category I alert (has the potential to become a serious problem) in Georgia, and on a watch list in Alabama and Tennessee (ALIPC, 2012; Evans, 2011a; GA-EPPC, 2006; Henry and Rohling, 2011; Homoya, 2010; KY-EPPC, 2013; TNEPPC, n.d.).

WRA area[1]: Entire United States, including territories.

1. *Achyranthes japonica* analysis

Establishment/Spread Potential

Achyranthes japonica is considered invasive in the United States (Evans, 2010, 2011a; Evans and Taylor, 2011; Henry and Rohling, 2011; SICWMA, n.d.; UGA-CISEH, 2011). This herbaceous perennial can reach heights of 2 meters and produce up to 16,000 seeds per square meter (Evans and Taylor, 2011). The growing season begins in mid- to late-April and continues through September (Henry and Rohling, 2011). Mature seeds can be present on upright plants from mid-August through mid-February (Henry and Rohling, 2011). Seeds have bracts that allow them to stick to clothes, equipment, and fur, making the plant easily spread by people and passing animals. Traits contributing to its risk score include shade tolerance, its propensity to form dense thickets, prolific seed production, unintentional distribution by people, and external distribution by animals. This assessment element had low uncertainty.

Risk score = 17 Uncertainty index = 0.11

Impact Potential

The impact potential of *A. japonica* is moderate because it is primarily a pest of natural areas. It spreads rapidly in and along riparian areas and displaces other species (Evans, 2010; Evans and Taylor, 2011). It may affect Federal Threatened and Endangered species. It is being actively controlled in most states into which it has been introduced through manual, chemical, and mechanical means (SICWMA, n.d.; UGA-CISEH, 2011). In the United States, it invades greenways and lawns in urban areas along forest edges (UGA-CISEH, 2011), although little current information exists on impacts in urban areas. It is reported as a common agricultural weed in its native range (Holm et al. 1979; Kawagoe and Kayama 1978). Our uncertainty rating for this element was high, mainly due to our lack of knowledge about its behavior in agricultural systems.

Risk score = 2.3 Uncertainty index = 0.43

[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)].

Geographic Potential Based on three climatic variables, we estimate that 38.5 percent of the United States is suitable for the establishment of *A. japonica* (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. japonica* represents the joint distribution of Plant Hardiness Zones 5-10, areas with 30-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: humid subtropical, marine west coast, humid continental warm summers, and humid continental cool summers.

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 or expand the areas in which this species is likely to establish. *Achyranthes japonica* is a temperate species that appears to grow best in moist, rich soils, from deep shade to full sun (Evans, 2011a; Evans and Taylor, 2011).

Entry Potential We did not assess the entry potential of *Achyranthes japonica* because it is already present in the United States (Evans and Taylor, 2011).

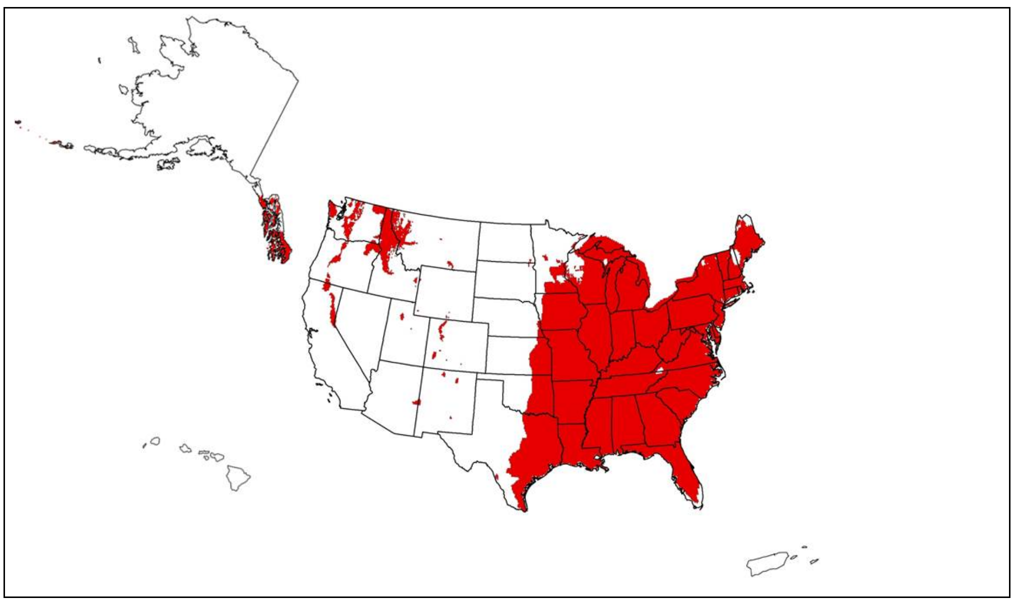

Figure 1. Predicted distribution of *Achyranthes japonica* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

2. Results and Conclusion

Model Probabilities: P(Major Invader) = 77.8%
P(Minor Invader) = 21.3%
P(Non-Invader) = 0.9%

Risk Result = High Risk

Secondary Screening = Not applicable

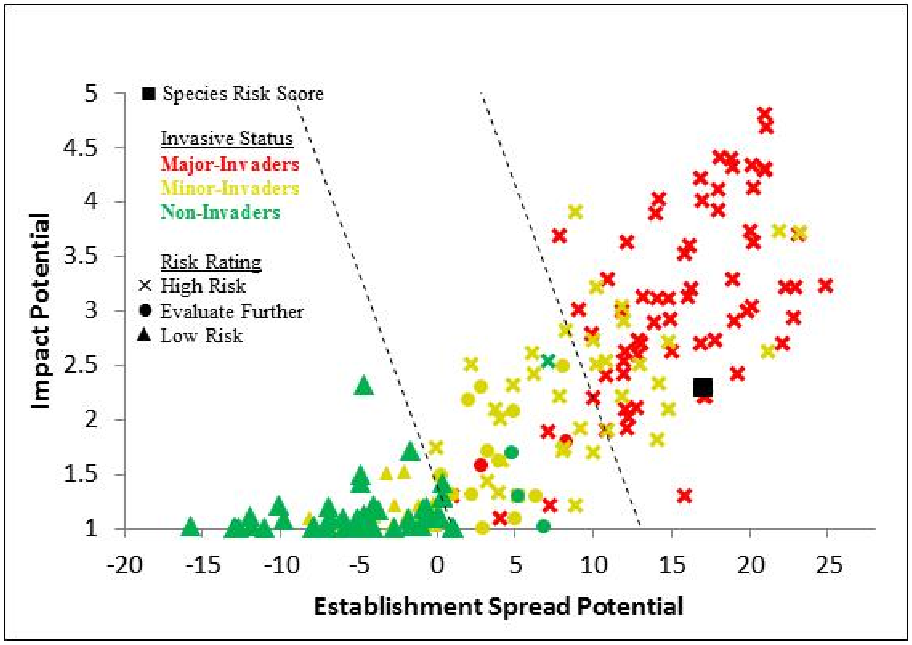

Figure 2. *Achyranthes japonica* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

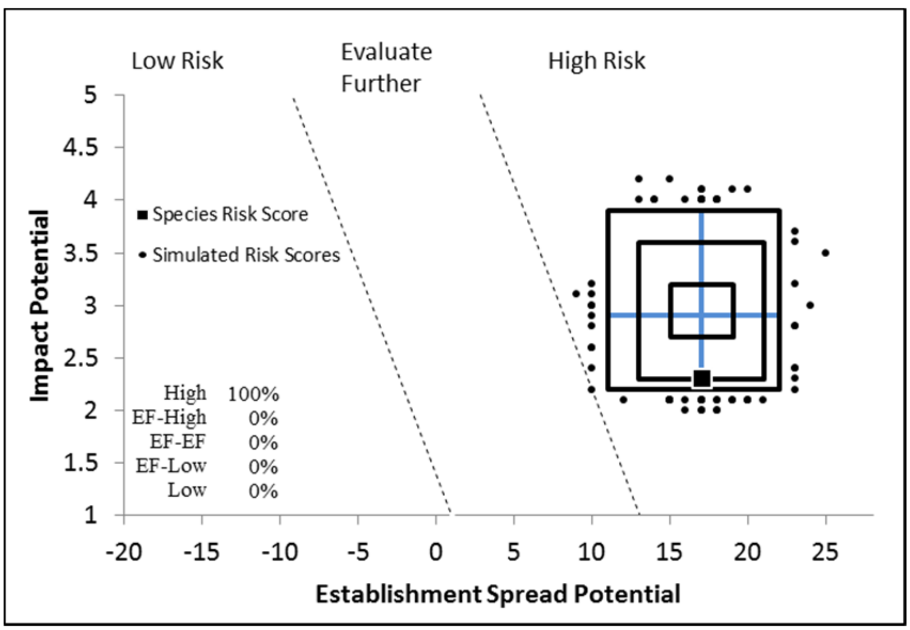

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk scores for *Achyranthes japonica*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *A. japonica* is High Risk (Fig. 2). Despite the relatively high uncertainty associated with impact potential, our result is statistically robust based on the Monte Carlo simulation (Fig. 3). This species clearly harms natural systems by outcompeting native species (Evans and Taylor, 2011). It is a problem on small Korean islands, where it kills petrels (seabirds) by trapping the adults within entangling seed heads (Choi, 2010; Pearson, 2010). It may become problematic in urban areas, where it invades lawns adjacent to infested forest edges (UGA-CISEH, 2011). *Achyranthes japonica* is being actively controlled in the United States —most often with glyphosate-based herbicides—and managers are trying to slow its spread or eradicate it from new areas (Henry and Rohling, 2011; UGA-CISEH, 2011).

Most of our uncertainty regards the types of impacts *A. japonica* may have in production systems. Although we found no specific evidence of impacts in these systems, it is reported as a common agricultural weed in its native range (Holm et al., 1979; Kawagoe and Kayama 1978). Limited access to Asian literature may have affected our ability to properly assess this species' impact potential in production systems. To date, *A. japonica* has not shown itself to be a pest in agricultural systems in the United States (Schwartz et al., 2010). Mature fruit is present from mid-August through mid-February (Henry and Rohling, 2011). Seeds can move on clothing or fur, and 60 percent germinate immediately (Evans, 2011a). Some level of infestation could occur in row crops (e.g., soybeans) if seeds are widely distributed in fields, although annual plowing should minimize any long-term establishment of plants. The species is non-rhizomatous and young plants are single-stemmed (Evans and Taylor, 2011). Seed longevity is not fully known (Evans and Taylor, 2011); however, rapid germination rates and low density seed bank suggests that seeds do not persist in the soil for an extended period of time (Shupert and Gibson, 2012). It is not likely to become a pest in flooded rice fields because it does not tolerate annual flooding or long periods of inundation (Evans, 2011a).

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Appendix A. Weed risk assessment for *Achyranthes japonica* (Miq.) Nakai (Amaranthaceae). 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)	f - negl	5	This taxon is native to eastern Asia; it is described as invasive in Illinois (Evans, 2010, 2011a; Evans and Taylor, 2011). It is introduced in the United States and has escaped in KY, WV, and northern AL (Weakley, 2010). It is reported as being in eight states in the United States (Swearingen, 2010). The alternate answers for the Monte Carlo simulation were e & e.
ES-2 (Is the species highly domesticated)	n - low	0	We found no evidence of domestication. In its native range this species is an important medicinal plant (Chang and Woo, 2003; Han et al., 2005). Extracts have proven useful in control against powdery mildew (Kim et al., 2004); however, we found no evidence of breeding that would affect its weed potential.
ES-3 (Weedy congeners)	y - negl	1	There are 8-10 species in the genus *Achyranthes* (Mabberly 2008), four of which are considered weeds (Randall 2012). Of these, *A. aspera* is considered a significant weed in Afghanistan, the Congo, Ecuador and Honduras, and a principle weed in Colombia, Ghana, Indonesia, India, and Kenya (Holm et al., 1979). It is also a weed of sugarcane in Pakistan (Qureshi et al., 2002).
ES-4 (Shade tolerant at some stage of its life cycle)	y - negl	1	This species can grow in deep shade (Evans, 2011a; Evans and Taylor, 2011).
ES-5 (Climbing or smothering growth form)	n - negl	0	*Achyranthes japonica* is an herbaceous perennial, and grows up to 5-6 feet in height (Evans, 2011a; Evans and Taylor, 2011).
ES-6 (Forms dense thickets)	y - negl	2	Dense infestations have been found in bottomland forests, riverbanks, field edges, and ditches (Evans, 2010). This species forms dense stands and can grow at densities of up to 70+ plants per square meter (Evans, 2011a). This taxon forms very dense thickets (Evans, 2011a).
ES-7 (Aquatic)	n - negl	0	This is a terrestrial plant; it grows best in areas with partial sun and moist soils but can also grow in heavily shaded and drier environments (Evans, 2010). This taxon does not tolerate annual flooding or long periods of inundation (Evans and Taylor, 2011).
ES-8 (Grass)	n - negl	0	*Achyranthes japonica* is in the family Amaranthaceae and is not a grass.
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	*Achyranthes japonica* is classified as a forb/herb (Swearingen, 2010) rather than woody. We found no evidence that it or any species in the family Amaranthaceae fixes nitrogen (Martin and Dowd, 1990).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	This plant can produce an abundance of seed (Evans, 2010). Preliminary results of seed viability test indicate that nearly 100 percent of seeds are viable and greater than60 percent germinate right away (Evans and Taylor, 2011).

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
ES-11 (Self-compatible or apomictic)	? - max	0	We found no evidence of apomixis; this is a well-known species.
ES-12 (Requires special pollinators)	n - low	0	In its native range, *A. japonica* is pollinated by wild bees, both solitary and social (Putra and Nakamura, 2009).
ES-13 (Minimum generation time)	c - low	0	*Achyranthes japonica* is an herbaceous perennial (Evans, 2011a; Evans and Taylor, 2011). This species begins growing in late spring, “comes on” in mid to late summer, flowers late summer, sets seed rapidly (late summer-early fall), seeds mature in early fall, and the plant senesces in late fall (Evans, 2011a). Many plants observed in the field appeared never to have flowered and were smaller than plants that had flowers; this suggests it may take one or two years to reach flowering size from seed (Evans and Taylor, 2011). The alternate answers for the Monte Carlo simulation were d and d.
ES-14 (Prolific reproduction)	y - negl	1	This species can produce an abundance of seed (Evans, 2010). Seed production estimated to be up to 16,000 seeds per square meter (Evans, 2011a; Evans and Taylor, 2011).
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	Each fruit has a pair of stiff bracts that aid the fruit in attaching to clothes or fur; seed is easily transported by sticking to shoes, clothing, or animal fur via the stiff, recurved bracts (Evans, 2010). Human-aided spread potential: hikers, hunters, stream anglers, campers, loggers/foresters, bird watchers, invasive plant work, site maintenance, road maintenance (Evans, 2011a).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	? - max	0	Unknown.
ES-17 (Number of natural dispersal vectors)	3	2	Fruit and seed traits for ES-17a through ES17e: The flowers occur on erect spikes at the end of the stems and upper branches. Flowers are small, lack petals, and occur in a tight cluster. When the fruit are formed, the spikes elongate greatly and the fruit lay flat against the spike (Evans, 2010). The fruits are slender and dry, with a single hard seed; each fruit has a pair of stiff bracts that aid the fruit in attaching to clothes or fur (Evans and Taylor, 2011).
ES-17a (Wind dispersal)	n - low		We found no evidence of wind dispersal.
ES-17b (Water dispersal)	y - negl		The plant grows in flood plains and stems with seeds are easily broken by flood waters; seed-bearing stems buried in silt can result in dense patches of seedlings (Evans and Taylor, 2011). There is no evidence the stems themselves take root.
ES-17c (Bird dispersal)	y - low		Korean researchers found seeds of Japanese chaff flowers (*Achyranthes japonica*) attached to three species of migratory birds (Eurasian Bittern *Botaurus stellaris*, Swinhoe's Rail *Coturnicops exquisitus* and Oriental Turtle Dove *Streptopelia orientalis*); the results suggest that migratory birds may be potential dispersing agents for *A. japonica* (Choi et al., 2010). Seeds could be picked up on bird feathers (Evans, 2011a).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17d (Animal external dispersal)	y - negl		"Each fruit has a pair of stiff bracts that aid the fruit in attaching to clothes or fur…plant produces an abundance of seed that is easily transported by sticking to…animal fur via the stiff, recurved bracts" (Evans, 2010).
ES-17e (Animal internal dispersal)	n - low		We found no evidence that the fruit is consumed and dispersed by animals.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	n - mod	-1	Rapid germination rates and low density seed bank imply that seeds do not persist in soil for an extended period of time (Shupert and Gibson, 2012).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - mod	1	This species does not appear to benefit from mutilation, but it appears tolerant: mowing does not deter its spread into lawns from forest edges (SICWMA, n.d.). Heavy deer browse does not limit growth (Evans and Taylor, 2011).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - mod	0	We found no evidence of herbicide resistance. This species is not listed as an herbicide resistant weed (Heap, 2011); however, species within the family Amaranthaceae have shown resistance to herbicides (Bryson, 2011).
ES-21 (Number of cold hardiness zones suitable for its survival)	6	0	
ES-22 (Number of climate types suitable for its survival)	4	2	
ES-23 (Number of precipitation bands suitable for its survival)	8	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	We found no evidence suggesting allelopathy and this is a well-studied species. In fact, *A. japonica* is often used in studies testing the allelopathy of other species (e.g., Singh et al., 1999; Yun and Choi, 2003).
Imp-G2 (Parasitic)	n - negl	0	*Achyranthes japonica* does not belong to a family that contains parasitic species (Nickrent, 2011).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	n - mod	0	We found no evidence of ecosystem changes.
Imp-N2 (Change community structure)	n - high	0	We found no evidence of this type of impact, and this species is well-studied. Because it forms thickets, can displace other species, and grows in forested areas, it could possibly change forest structure by outcompeting regenerating trees. Consultation with an expert revealed that it may be able to shade out seedlings, but it does not leave a dense thatch so it would not restrict tree seeds from contact with the soil (Evans, 2011b). Trees that grow in the forest interior are often shade-tolerant and grow slowly, and those that grow in sun patches or openings grow very quickly; once a tree has acquired dominance in height over this species, it is not likely to be outcompeted for resources. We answered no, but

Question ID	Answer - Uncertainty	Score	Notes (and references)
			with high uncertainty, because there may be some instances where a patch is dense enough to outcompete tree seedlings and prevent forest regeneration.
Imp-N3 (Change community composition)	y - negl	0.2	This species forms very dense thickets, near monoculture; it seems to exclude many other species, even displacing stiltgrass (*Microstegium vimineum*) (Evans, 2011a). *Achyranthes japonica* plants kill petrels (seabirds) in Korea by trapping the adults within entangling seed heads; the adults are trapped when returning to their burrows to feed young, which soon perish from lack of parental care (Pearson, 2010). These introduced plants are threatening the petrels with extirpation (estimated to take place in 33 to 35 years, if the plants are not controlled) (Choi, 2010).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	y - low	0.1	This species forms extensive infestations along riverine systems (Evans, 2011a; Evans and Taylor, 2011). Its habitat includes floodplains, bottomland forests,along rivers and ditches, and old fields (Evans, 2011a; Evans and Taylor, 2011). Because these are often habitats that include threatened and endangered species, and because there is evidence of *A. japonica* displacing other species (see Imp N3), we answered yes with low uncertainty.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	n - mod	0.1	There are outstanding ecoregions in California, the Pacific Northwest, and the eastern United States (Ricketts et al., 1999) that, based on the predicted distribution of *A. japonica*, could be affected by this taxon. However, because we found no evidence of this species changing ecosystem processes or plant community structure, we answered no with moderate uncertainty.
Imp-N6 (Weed status in natural systems)	c - negl	0.6	This species is viewed unquestionably as a weed of natural areas (Evans, 2010, 2011a; Evans and Taylor, 2011). Control methods in natural areas have included manual, mechanical and chemical 2% solution of triclopyr- or glyphosate-based herbicide treatments (SICWMA, n.d.). The alternate answers for the Monte Carlo simulation were b & b.
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	n - mod	0	We found no evidence; this is a well-studied species.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	We found no evidence; this is a well-studied species.
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	y - mod	0.1	Dense stands of *A. japonica* spread from forest edges into lawns; appears to spread quickly along waterways and public areas like trails; mowing does not deter this plant (SICWMA, n.d.).
Imp-A4 (Weed status in anthropogenic systems)	b - high	0.1	In Indiana, the plant appears to be a weed in any environment in which it is found, including forest/urban interface areas (lawns adjacent to forested areas) (SICWMA, n.d.). Throughout its introduced range in the United States, it has been found in a variety of settings

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
			including yards/gardens, and it is treated (dug up and bagged) wherever it is found (UGA-CISEH, 2011). However, because we found no specific evidence stating it was directly controlled in anthropogenic systems, we are answering b with high uncertainty. The alternate answers for the Monte Carlo simulation were c and a.
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	? - max		Unknown; it is reported as an agricultural weed (Randall, 2007; Holm 1979; Kawagoe and Kayama 1978) and included in agricultural weed-control studies in Japan (Suaghara, 1981), but details are minimal. It is present in Tennessee and classified as a "Tier 1" (high to medium threat to agriculture and/or natural ecosystems) weed (UTN, n.d.). Little information on its behavior in agricultural systems in the United States is available; one study looking at its effect on soybean growth showed no negative effect on soybean (Schwartz et al., 2010).
Imp-P2 (Lowers commodity value)	? - max		Unknown (see comments for Imp-P1).
Imp-P3 (Is it likely to impact trade)	? - max		Unknown (see comments for Imp-P1).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	? - max		Unknown; it is reported as an agricultural weed in its native range (Randall, 2007; Holm 1979; Kawagoe and Kayama 1978) and included in agricultural weed-control studies in Japan (Suaghara, 1981), but details are minimal.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	? - max		Deer browse heavily (Evans, 2011a; Evans and Taylor, 2011). Described as an abortifacent (roots) for humans (WHO, 1998), so mammal consumption of roots could cause miscarriage.
Imp-P6 (Weed status in production systems)	b - high	0.6	It is reported as a common agricultural weed in Japan (Holm 1979; Kawagoe and Kayama 1978). In its native range, studies related to agricultural weeds have shown that decreasing the pH levels of soils to control weeds can be effective; the lethal pH level for *A. japonica* was found to be 5.4 (Suaghara, 1981). This evidence suggests that it is controlled in its native range; however, the above-referenced study included many native weeds and otherwise we found no direct evidence of control. The alternate answers for the Monte Carlo simulation were c and a.
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically-referenced coordinates obtained from the Global Biodiversity Information Facility (GBIF, 2011).
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - low	N/A	We found no evidence of its presence in this hardiness zone.
Geo-Z2 (Zone 2)	n - low	N/A	We found no evidence of its presence in this hardiness zone.
Geo-Z3 (Zone 3)	n - low	N/A	We found no evidence of its presence in this hardiness zone.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z4 (Zone 4)	n - low	N/A	We found no evidence of its presence in this hardiness zone.
Geo-Z5 (Zone 5)	y - low	N/A	North Korea.
Geo-Z6 (Zone 6)	y - negl	N/A	United States (IN, OH) (UGA-CISEH, 2011); South Korea.
Geo-Z7 (Zone 7)	y - negl	N/A	United States (KY, IL, OH, WV, TN) (UGA-CISEH, 2011); South Korea, Japan.
Geo-Z8 (Zone 8)	y - negl	N/A	United States (AL, GA) (UGA-CISEH, 2011).
Geo-Z9 (Zone 9)	y - low	N/A	We found no specific evidence it occurs in this hardiness zone, but because it occurs in hardiness zones 8 and 10, there is no reason why it wouldn't be able to survive in this zone.
Geo-Z10 (Zone 10)	y - negl	N/A	Taiwan.
Geo-Z11 (Zone 11)	n - low	N/A	We found no evidence of its presence in this hardiness zone.
Geo-Z12 (Zone 12)	n - negl	N/A	We found no evidence of its presence in this hardiness zone.
Geo-Z13 (Zone 13)	n - negl	N/A	We found no evidence of its presence in this hardiness zone.
Köppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence of its presence in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence of its presence in this climate class.
Geo-C3 (Steppe)	n - negl	N/A	We found no evidence of its presence in this climate class.
Geo-C4 (Desert)	n - negl	N/A	We found no evidence of its presence in this climate class.
Geo-C5 (Mediterranean)	n - low	N/A	We found no evidence of its presence in this climate class.
Geo-C6 (Humid subtropical)	y - negl	N/A	United States (IL, IN, KY, WV, TN, AL, GA) (UGA-CISEH, 2011); South Korea, Taiwan, Japan.
Geo-C7 (Marine west coast)	y - mod	N/A	Yunnan Province (China) (Zhou and Wang, 2005)
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	United States (IN, OH) (UGA-CISEH, 2011); North Korea, South Korea.
Geo-C9 (Humid cont. cool sum.)	y - low	N/A	Nara (Hokkaido, Japan).
Geo-C10 (Subarctic)	n - low	N/A	We found no evidence of its presence in this climate class.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence of its presence in this climate class.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence of its presence in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - negl	N/A	We found no evidence of its presence in this precipitation band.
Geo-R2 (10-20 inches; 25-51 cm)	n - negl	N/A	We found no evidence of its presence in this precipitation band.
Geo-R3 (20-30 inches; 51-76 cm)	n - low	N/A	We found no evidence of its presence in this precipitation band.
Geo-R4 (30-40 inches; 76-102 cm)	y - mod	N/A	Yunnan Province (China) (Zhou and Wang, 2005).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	USA (IL, IN, KY, OH, WV) (UGA-CISEH, 2011); North Korea, South Korea.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	USA (TN, AL, GA) (UGA-CISEH, 2011); South Korea.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Japan.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Japan.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Taiwan.
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Japan (ARS-GRIN, 2011).
Geo-R11 (100+ inches; 254+ cm))	y - negl	N/A	Japan (ARS-GRIN, 2011).
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	Introduced into the United States and found in nine states (AL, GA, IL, IN, KY, OH, TN) (Bryson, 2011; Evans, 2010; UGA-CISEH, 2011).
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 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	
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	