Weed Risk Assessment for *Arundo donax* L. (Poaceae) – Giant reed

United States
Department of
Agriculture

Animal and Plant
Health Inspection
Service

June 14, 2012

Version 1

Aerial view of *Arundo donax* near Big Bend National Park, Texas (left), and near Eagle Pass, Texas, along the Rio Grande (right). Source: Photographs taken by John Goolsby and obtained from http://www.ars.usda.gov/is/AR/archive/jul09/arundo0709.htm.

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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 "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.

Arundo donax L. – Giant reed

Species Information

Family: Poaceae

Initiation: This WRA on *Arundo donax* is an update to a 2006 Canadian Food Inspection Agency (CFIA) WRA. The 2006 WRA was initiated in response to a proposal to import and cultivate *Arundo donax* in British Columbia in trials for pulp and paper production. A risk management document, RMD 07-01, *Importation, movement and use of* Arundo *species, including* A. donax *in Canada*, underwent stakeholder consultation in 2007. Although it was recommended that importation be allowed under restrictive conditions, no final decision was made. Currently, renewed interest in this species exists in Canada, specifically to explore its use for ethanol and chemical production in Ontario. Similar interest has been expressed in Oregon and North Carolina in the United States (Mack, 2008). We were asked to update the WRA to determine if its risk potential has changed since 2006, and to aid in regulatory decision-making on *A. donax*. A CFIA weed risk analyst completed this assessment using the PPQ WRA process. It was reviewed by PPQ prior to clearance.

Foreign distribution: *Arundo donax* is native to many tropical and temperate regions from northern Africa and the Middle East eastwards through eastern and southeastern Asia (CABI, 2011a). It has been introduced into similar climates around the world in southern Europe, Central America, South America, and the Caribbean. It is invasive in southern Africa, the western United States, southern Europe, and the Azores (Weber, 2003).

Canadian distribution and status: *Arundo donax* is present in Canada, but only in cultivation. It is available from some garden centers and nurseries in southern Ontario and southern British Columbia, and possibly elsewhere (CNLA, 2008;

[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

Isaacson and Allen, 2007). It has also been grown in botanical gardens in Canada (e.g., Vancouver, BC, Niagara Falls, ON, and Montreal, QC). It is not reported to occur in natural ecosystems in Canada (Brouillet et al., 2010; Scoggan, 1979).

U.S. distribution and status: *Arundo donax* has naturalized in 25 states, as well as Puerto Rico and the Virgin Islands (Kartesz, 2011; NRCS, 2011). It is particularly abundant along rivers in California and Texas. This species grows best in moist, well-drained soils along ditches, streams, and riverbank and lake borders (ISSG, 2011). However, it tolerates a wide range of conditions, including saline soils and areas affected by drought (Hoshovsky, 1986; Perdue, 1958). Additional habitats include agricultural areas, coastlands, deserts, disturbed areas, natural and planted forests, rangelands, grasslands, scrublands and urban areas (ISSG, 2011). It grows well under cultivation. *Arundo donax* is listed as a noxious weed in California, Nevada and Texas (USDA-ARS, 2011).

WRA area: All of Canada and the United States, including territories.

1. *Arundo donax* analysis

Establishment/Spread Potential *Arundo donax* is a highly invasive grass. It is widely naturalized around the world and invasive in many countries, including the United States, Mexico, South Africa, and Australia (CABI, 2011a). This species grows quickly and forms dense thickets in riparian areas. Though not known to produce seeds where introduced, dispersal occurs when rhizome pieces break off plants after disturbance and are carried downstream where they quickly establish new plants (Weber, 2003). *Arundo donax* is highly flammable and recovers faster than native species after fires (ISSG, 2011). We had low uncertainty with this risk element.

Risk score = 13 Uncertainty index= 0.11

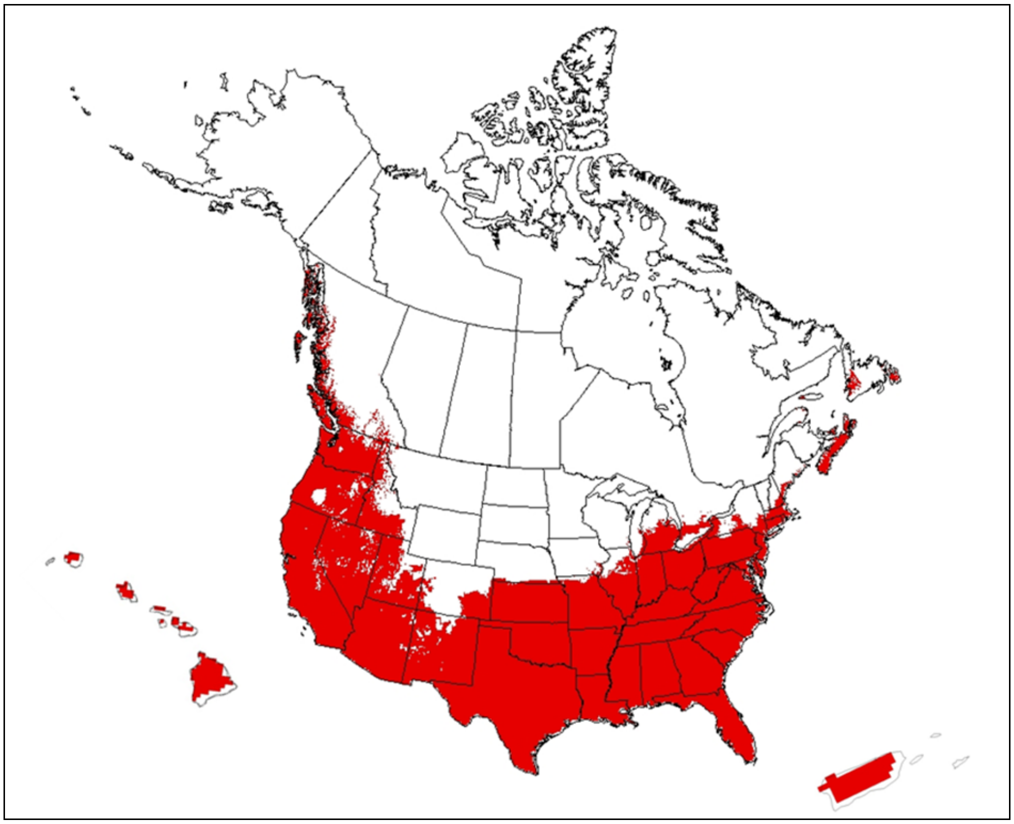
Impact Potential *Arundo donax* is a serious environmental weed. It alters the hydrology, nutrient cycling, and fire regime of infested areas (ISSG, 2011). It negatively affects community composition and structure by displacing native vegetation and transforming areas into tall grass monocultures. Negative effects on threatened and endangered species have also been documented, such as with the Least Bell's Vireo (*Vireo bellii*) (ISSG, 2011). *Arundo donax* also affects city and recreational areas. For example, it affects the navigability of watercourses (Csurhes, 2009). During storms, large masses of plant material can become dislodged and accumulate around bridges, culverts and other structures, impairing their function (Coffman et al., 2004). *Arundo donax* uses water heavily, reducing water resources to communities downstream (Csurhes, 2009). We had very little uncertainty with this risk element.

Risk score = 3.3 Uncertainty index = 0.06

Geographic Potential We estimate that about 57 percent of the United States and 2 percent of Canada is suitable for the establishment of *A. donax* (Fig. 1). We based that on the species' distribution elsewhere in the world, including point-referenced localities and areas of occurrence obtained primarily from the Global Biodiversity Information Facility (GBIF, 2011). The map for *A. donax* represents the joint distribution of USDA Plant Hardiness Zones 6-13, areas with 0-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, steppe, desert, mediterranean, humid subtropical, humid continental warm summers, humid continental cool summers, and marine west coast.

Entry Potential We did not assess this risk element, because *A. donax* is already present in Canada and the United States (Kartesz, 2011; NRCS, 2011)..

Figure 1. Predicted distribution of *Arundo donax* in the United States and Canada. Map insets for Hawaii, and Puerto Rico are not to scale.



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 71.4%
P(Minor Invader) = 27.4%
P(Non-Invader) =1.2%

Risk Result = High Risk

Secondary Screening = Not Applicable

Figure 2. *Arundo donax* 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.

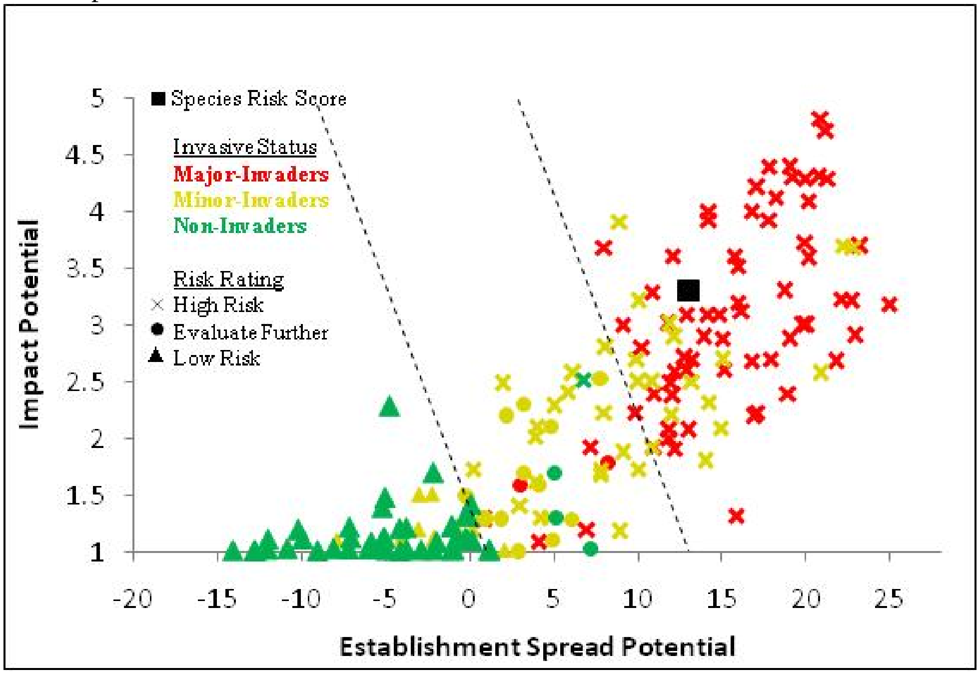
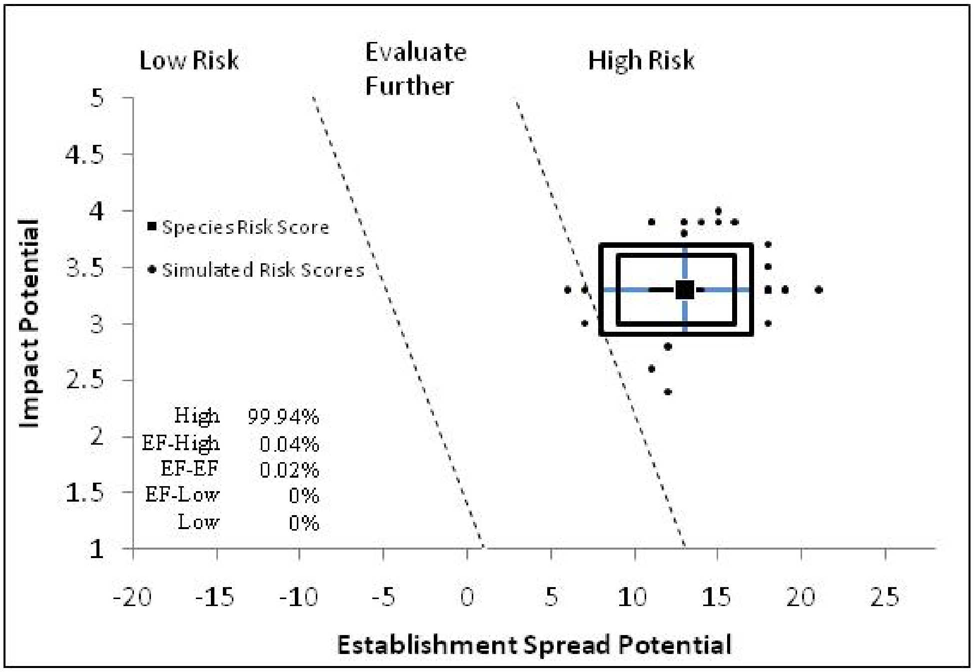


Figure 3. Monte Carlo simulation results (N=5000) for uncertainty around *Arundo donax*'s risk scores[a].



[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 weed risk assessment for *A. donax* is High Risk (Fig. 2). This result is consistent with *A. donax*'s strong history of invasion elsewhere, including in the United States. *Arundo donax* is considered by some to be a "transformer" species (Csurhes, 2009) because it dramatically alters habitats and ecological processes. It is a serious invader of riparian areas and is also known to impact cities and recreational areas. Control is very expensive and requires destruction or devitalization of the entire rhizome system. In one study, the cost of control in areas of coastal California was calculated to be $25,000 (US) per acre (Giessow et al., 2011). Research on the biological control of *A. donax* in the United States has led to the recent release of a wasp, *Tetramesa romana* Walker (Hymenoptera: Eurytomidae) (Goolsby et al., 2009; Racelis et al., 2009).

It should be noted that *A. donax* has a long history of cultivation and has been used for a wide variety of purposes (e.g., reed-making for musical instruments, basketry, construction materials, medicinal and culinary purposes, erosion control). Its very fast growth has also drawn interest for its potential to produce biofuel, fiber, and pulp (CABI, 2011b).

Uncertainty was generally low for this assessment because we found direct evidence for many of the questions, and often from multiple sources. Uncertainty had little impact on the final conclusion of this assessment, and we believe there is sound justification for the High Risk rating. Our results and conclusions are similar to those of other risk assessments that have been done on *A. donax* (e.g., Csurhes, 2009; US Forest Service, 2012).

Limited mostly by cold temperatures, our analysis indicates that about 2 percent of Canada and 57 percent of the United States is suitable for the establishment of *A. donax*. In Canada, the areas at risk from *A. donax* are southwestern and south-central British Columbia, southern Ontario, and parts of the Maritime provinces. In the United States, much of the area is at risk with the exception of the coldest areas of central and extreme north-eastern United States (below Plant Hardiness Zone 6) and Alaska. *Arundo donax* is present throughout much of the suitable area already, with the exception of Washington, Oregon and some of the north-eastern states. Within the areas suitable for *A. donax*, riparian zones are at greatest risk.

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Appendix A. Weed risk assessment for *Arundo donax* L. (Poaceae). 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	"Native to tropical and temperate regions of the Old World…now widely dispersed into all similar climates of the world, and has also become naturalized and invasive in many regions" (CABI, 2011a). First imported into California by Spanish settlers in the early 1500s (Csurhes, 2009), though Bell (1997) states it was introduced into California in the 1820s (introduced long ago). "Over the last 25 years the riparian forests of coastal southern California have become infested with *A. donax*" (Bell, 1997). "Able to quickly invade new areas..." (ISSG, 2011). The alternate answers for the Monte Carlo simulation are both "e."
ES-2 (Domesticated to reduce weed potential)	n - negl	0	Though cultivated, no evidence of selection for reduced weed potential. The variegated *A. donax* var. *versicolor* is shorter and not as hardy as the green *A. donax*. Barkworth et al. (2003) also mention the cultivar 'Macrophylla' which has unusually wide leaves.
ES-3 (Weedy congeners)	n - low	0	*Arundo* is a genus of three species from Asia and the Mediterranean. The other two species are *A. formosana* and *A. plinii* (Csurhes, 2009). No serious or principal weeds in this genus are included in Holm et al. (1991). Only *A. donax* is listed in Weber (2003). The other two species are not listed as weeds in USDA-ARS (2011). Randall (2007) describes *A. formosana* as a weed and *A. plinii* as naturalized, but they do not seem to be major weeds.
ES-4 (Shade Tolerance)	n - mod	0	Grows best where abundant sunlight is available (ISSG, 2011). "Dominant in open sites (full sun)" (Csurhes, 2009). "Light: full sun". But "giant reed also can colonize within native stands of cottonwoods, willows, and other riparian species, even growing in sites shaded by tree canopy" (Bossard et al., 2000). Despite some conflicting information, answering no because this species seems unlikely to grow in full shade (possibly partial shade). Accordingly, uncertainty is raised to mod.
ES-5 (Climbing or smothering growth form)	n - negl	0	This species is a tall grass that forms large spreading clumps (ISSG, 2011). It is not a vine and does not form rosettes.
ES-6 (Dense Thickets)	y - negl	2	It produces many-stemmed tussocks (Weber, 2003). It forms "large, continuous, clonal root masses, sometimes covering several acres" (ISSG, 2011). The Global Invasive Species Database (ISSG, 2011) also refers to "dense populations". In Hawaii, it has "naturalised in coastal areas, often in thickets" (Wagner et al., 1999). "Large and medium sized mammals cannot penetrate in

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
			densely infested areas" (Coffman et al., 2004).
ES-7 (Aquatic)	n - negl	0	This species is a hydrophyte and establishes in moist places such as ditches, streams, and river banks with abundant moisture (ISSG, 2011). "In wetter regions, such as Fiji, *A. donax* persists further away from riparian habitats, including areas described as 'hillsides, open forest and along roadsides, up to about 200 m elevation' (Smith, 1979)" (Csurhes, 2009). Perdue (1958) reported *A. donax* at an altitude of 2,438 m in the Himalayas (presumably in a moist site). Grows in a variety of non-aquatic habitats (e.g., roadsides, managed grasslands, open forest, plantations) (CABI, 2011a). Although it prefers moist areas, it survives and reproduces vegetatively in dry upland areas as well.
ES-8 (Grass)	y - negl	1	Belongs to the Poaceae family (USDA-ARS, 2011; Weber, 2003).
ES-9 (N2-fixer)	n - negl	0	Species is in the Poaceae family, which is not known to contain N-fixing plants (Martin and Dowd, 1990). Not woody.
ES-10 (Viable seeds)	y - mod	1	Very little is known about its sexual reproduction (ISSG, 2011). "Although plants have been grown in scattered locations from seed collected in Asia, it is reported that *A. donax* does not produce viable seeds in most areas where it is apparently well-adapted" (CABI, 2011a). "The lack of seed production in Arundo in many parts of the world appears to be due to an inability to develop mature megagametophytes. This suggests infertility is limited by genetic factors, rather than climatic ones. Thus seed production will probably depend more on the specific genotype(s) introduced and whether spontaneous mutation might restore some fertility" (S. Darbyshire, pers. comm.). According to Oakes (1990), "propagated by seeding and by vegetative propagation, most commonly the latter." No seeds have been documented from North America or Europe (Saltonstall et al., 2010). "Johnson et al. (2006) examined more than 36000 florets and found only five ovules that may have been viable" (Csurhes, 2009). This species seems capable of producing seed in its native range but not in its introduced range. Answering “yes” because it is possible for it to produce viable seed, but using moderate uncertainty because it does not appear to be very common.
ES-11 (Self-compatible)	? - max	0	Unknown.
ES-12 (Specialized Pollinators)	n - low	0	"Uncertain, probably wind pollinated" (Starr et al., 2003). Species is a grass, which are primarily wind pollinated.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
ES-13 (Min generation time)	b - high	1	"Reproduces vegetatively. Much of the cultivation is initiated by planting rhizomes that root and sprout readily…New shoots arise from rhizomes in nearly any season, but most commonly in the spring. Growth also occurs in any season…*A. donax* grows very rapidly. Growth rates of up to 0.7 m/week have been recorded, putting it among the fastest growing terrestrial plants" (CABI, 2011a). It also reproduces vegetatively by layering (adventitious sprouting of roots on stem tips touching the ground; Boland, 2006). A PIER weed risk assessment for this question states "Probably less than a year since the species mostly spreads/reproduces by vegetative means" (US Forest Service, 2012). This species appears to be capable of forming new, potentially independent plants, in one year. It may be capable of more than one generation per year, but there is insufficient evidence of this. Therefore, answering "b" with high uncertainty. The alternate answers for the Monte Carlo simulation are "c" and "a".
ES-14 (Prolific reproduction)	n - negl	-1	Produces spikelets with 4-5 florets. No viable achenes are formed in North America (Weber, 2003). "Seeds are rarely produced" (Csurhes, 2009).
ES-15 (Unintentional dispersal)	y - negl	1	Spread by water after mechanical damage by motor boats or other water equipment in waterways. Also "may be spread locally by agricultural machinery." Spreads "through the disposal of garden waste" (CABI, 2011a).
ES-16 (Trade contaminant)	n - low	-1	Unlikely because it rarely produces seed. Although, note that USDA-ARS (2011) lists it as a potential seed contaminant.
ES-17 (#Natural dispersal vectors)	2	0	
ES-17a (Wind dispersal)	y - low		Inflorescence is a 0.3-0.6 m plume that stands above the foliage (ISSG, 2011). The hairy, light-weight disseminules (individual florets with the enclosed grain) are dispersed by wind (McWilliams, 2004). Seeds are dispersed by the wind (Csurhes, 2009). Even though this species does not produce seed in its introduced range, we answered "yes" because seeds are wind dispersed. It is possible that other genotypes capable of producing seed may be introduced into North America in the future.
ES-17b (Water dispersal)	y - negl		"Even small rhizome fragments can regrow and form new plants; rhizome fragments are carried by rivers and streams" (Weber, 2003). Floods break up clumps…and spread pieces downstream where they can take root and establish new clones (McWilliams, 2004). "Dispersal is achieved from broken sections of rhizomes and stems, which are readily carried by floodwater" (Csurhes, 2009).
ES-17c (Bird dispersal)	n - negl		No evidence; species well studied. Rarely produces seed, and birds not likely to disperse stem or rhizome

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
			fragments (propagules too large).
ES-17d (Animal external dispersal)	n - low		No clear adaptation for this type of dispersal [propagules are rhizome and stem fragments or (possibly) spikelets/florets in native range].
ES-17e (Animal internal dispersal)	n - negl		No evidence. Species well studied.
ES-18 (Seed bank)	? - max	0	Csurhes (Csurhes, 2009) did a risk assessment on this species but was unable to find information on seed longevity. McWilliams (McWilliams, 2004) did a review of this species and also did not find any information on this trait.
ES-19 (Tolerance to loss of biomass)	y - negl	1	"Dead shoots are highly flammable and the grass resprouts quickly after burning" (Weber, 2003). "Causes fires and recovers from them 3-4 times faster than native plants" (ISSG, 2011).
ES-20 (Herbicide resistance)	n - negl	0	No evidence of resistance. Species well studied. Not listed as having herbicide resistance by Heap (2012). Numerous references describe control techniques that use herbicides (e.g., CABI, 2011a).
ES-21 (# Cold hardiness zones)	8	0	
ES-22 (# Climate types)	9	2	
ES-23 (# Precipitation bands)	11	1	
Impact Potential			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	No evidence of allelopathy for plants *in situ*. Species well studied. There is some evidence of allelopathic activity of straw extracts against algae (Hong et al., 2011).
Imp-G2 (Parasitic)	n - negl	0	Poaceae is not one of the families known to contain parasitic plants (Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Ecosystem processes)	y - negl	0.4	"Invades riparian areas, altering the hydrology, nutrient cycling and fire regime" (ISSG, 2011). "In some riparian areas, fire has become the primary influence on plant community structure and floristic composition, rather than floods. Such changes to ecosystem function have led to some authors referring to *A. donax* as a 'transformer species'" (Csurhes, 2009). "Root masses, which can become more than a meter thick, stabilize stream banks and terraces (Zohary and Willis 1992), altering flow regimes" (Bell, 1997). "Riverine areas dominated by *A. donax* tend to have warmer water temperatures, which results in lower oxygen concentrations" (Bell, 1997).
Imp-N2 (Community structure)	y - negl	0.2	"It is the largest and tallest ornamental grass other than bamboo" (ISSG, 2011). "Alters habitats towards dense, monotypic stands up to 8 m tall….huge monocultures can cover hundreds of acres" (CABI, 2011a).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
Imp-N3 (Community composition)	y - negl	0.2	"Forms species poor clones" (Weber, 2003). Competes with and displaces native plants (ISSG, 2011). "Areas that once supported a mix of native plant species are now pure stands of *A. donax*" (Csurhes, 2009). "[*Arundo*] *donax* displaces native riparian vegetation" (CABI, 2011a).
Imp-N4 (T&E species)	y - negl	0.1	"Known to displace and reduce habitats for native species including the Federally endangered Least Bell's Vireo" (ISSG, 2011). Other workers "recorded only half the diversity and abundance of aerial invertebrates in stands of *A. donax*, compared with native vegetation, with some threatened species of birds relying heavily on invertebrates for food" (Csurhes, 2009). Displaces native vegetation and excludes associated wildlife species (Weber, 2003).
Imp-N5 (Globally outstanding ecoregions)	y - negl	0.1	Occurs in coastland, natural forests, riparian zones, scrub/shrublands (ISSG, 2011). Impacts have been documented in riparian areas (ISSG, 2011). There is significant overlap between the Kartesz (2011) map for this species and the Ricketts et al. (1999) map of globally outstanding ecoregions.
Imp-N6 (Natural systems weed)	c - negl	0.6	Environmental weed in Southern Africa, the Western United States, Southern Europe, and the Azores. To control it, all rhizomes must be removed. Effective herbicides are glyphosate or fluaziprop (Weber, 2003). A weed risk assessment for Queensland concluded that it has the potential to become a significant weed in certain riparian habitats in Queensland (Csurhes, 2009). Declared noxious in the Sydney regions of New South Wales, Australia and a Category 1 weed (a declared weed which must be controlled) in South Africa (ISSG, 2011). Bell (1997) describes details for controlling *A. donax* using a suite of methods. Alternate answers for Monte Carlo simulation were both "b."
Impact to Anthropogenic areas (cities, suburbs, roadways)			
Imp-A1 (Affects property, civilization, ...)	y - negl	0.1	Interferes with flood control (ISSG, 2011). "Its long, fibrous, interconnecting root mats…form a framework for debris behind bridges, culverts, and other structures that can affect their function" (ISSG, 2011). "In the Santa Ana River alone, *A. donax* is estimated to use drinking water valued at $18 million each year" (Csurhes, 2009). A recent environmental assessment stated that "the impact of *A. donax* in riparian habitats includes...damage to bridges; increased costs for chemical and mechanical control along transportation corridors. Its height and density causes problems for law enforcement activities on the US-Mexico border and also hampers stream navigability" (cited in Csurhes, 2009). "During large storm events large masses of *A. donax* may become lodged behind bridge and overpass structures resulting in additional flooding and in

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
			extreme cases loss of structure" (Coffman et al., 2004).
Imp-A2 (Recreational use)	y - low	0.1	Hampers navigability. "…quite troublesome in many river systems, preventing the usual recreation and angling activities" (Moreira et al., 1998).
Imp-A3 (Affects ornamental plants)	n - low	0	No evidence. Species well studied.
Imp-A4 (Anthropogenic weed)	c - mod	0.4	Arundo donax is generally considered a weed of disturbed and urban areas (ISSG, 2011; Quinn et al., 2009). There is evidence of control in an urban coastal saltmarsh (Gill, 2005). Alternate answers for Monte Carlo simulation were both “b.”
Impact to Production systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Crop yield)	n - low	0	"[*Arundo*] *donax* is not usually a weed of crops" (CABI, 2011a). No additional evidence found, species well studied.
Imp-P2 (Commodity Value)	n - mod	0	Unlikely to lower commodity value though considered potential seed contaminant by USDA-ARS (2011). This seems unlikely as it rarely produces seed. Possibly reduces commodity value through costs of control? But no evidence found for its impact on production systems.
Imp-P3 (Affects trade)	n - low	0	Declared noxious in the Sydney regions of NSW, Australia and a Category 1 weed (a declared weed which must be controlled) in South Africa (ISSG, 2011). Noxious in Texas, California and Nevada (USDA-ARS, 2011). Although listed as a potential seed contaminant (USDA-ARS, 2011), it largely reproduces vegetatively and is unlikely to be found as a contaminant.
Imp-P4 (Irrigation)	y - negl	0.1	"In arid parts of the USA, *A. donax* uses substantial amounts of ground-water, taking a resource that could otherwise be used by agriculture, people and wildlife" (Csurhes, 2009). "Stands of *A. donax* can consume up to 2000 litres of water per square meter of plants" (Csurhes, 2009). This species infests ditches adjacent to agricultural fields and waterways near places of human habitation.
Imp-P5 (Animal toxicity)	n - low	0	Grazing may be effective against *Arundo* (ISSG, 2011). "All livestock, including pigs and poultry, are attracted to it" (Perdue, 1958). "As fodder, only the young leaves are browsed; the stems are woody, and the grass unpalatable in later stages" (Duke, 1983). Not in Burrows and Tyrl (2001).
Imp-P6 (Production system weed)	a - mod	0	Not a serious or principal weed in Holm et al. (1991), though a "common" weed in two countries. Occurs in agricultural areas, planted forests, and rangelands (ISSG, 2011). Hafliger (Häfliger, 1980-1981) does not include crops among its habitats. Weed risk assessments from the Pacific, Florida, and the United States all answered "no" to the question of "weed of agriculture". This species is more of an environmental weed than an

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
			agricultural weed. Alternate answers for Monte Carlo simulation were both "b."
Geographic Potential			
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	NA	No evidence.
Geo-Z2 (Zone 2)	n - negl	NA	No evidence.
Geo-Z3 (Zone 3)	n - negl	NA	No evidence.
Geo-Z4 (Zone 4)	n - negl	NA	No evidence.
Geo-Z5 (Zone 5)	n - low	N/A	No evidence.
Geo-Z6 (Zone 6)	y - negl	N/A	Pakistan, U.S. (KS, IL, WV, NM) (GBIF, 2011); Switzerland, Ukraine (USDA-ARS, 2011).
Geo-Z7 (Zone 7)	y - negl	N/A	China, Pakistan, France, Spain, Mexico, U.S. (MD, VA, WV, KY, TN, NC, AR, NM, AZ, CA) (GBIF, 2011); Hungary, Switzerland (USDA-ARS, 2011).
Geo-Z8 (Zone 8)	y - negl	N/A	China, Pakistan, Greece, France, Spain, Portugal, Mexico, U.S. (NC, SC, GA, AL, MS, AR, LA, TX, NM, AZ, CA) (GBIF, 2011).
Geo-Z9 (Zone 9)	y - negl	N/A	Japan, Israel, Greece, Spain, Portugal, U.S. (SC, GA, FL, LA, TX, AZ, CA) (GBIF, 2011).
Geo-Z10 (Zone 10)	y - negl	N/A	China, Israel, Portugal (GBIF, 2011); Laos, Myanmar, U.S. (HI), Guatemala, Uruguay (USDA-ARS, 2011).
Geo-Z11 (Zone 11)	y - low	N/A	Native: Laos, Myanmar, Thailand, Vietnam; Naturalized: U.S. (HI), Costa Rica, Guatemala, Nicaragua, Venezuela (USDA-ARS, 2011).
Geo-Z12 (Zone 12)	y - low	N/A	Native: Cambodia, Myanmar, Thailand, Indonesia, Malaysia; Naturalized: U.S. (HI), Costa Rica, El Salvador, Nicaragua, West Indies, Venezuela (USDA-ARS, 2011).
Geo-Z13 (Zone 13)	y - low	N/A	Native: Cambodia, Indonesia, Malaysia; Naturalized: U.S. (HI), El Salvador, Nicaragua, Suriname (USDA-ARS, 2011).
Koppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - low	N/A	Native: Cambodia, Laos, Myanmar, Thailand, Vietnam, Indonesia, Malaysia; Naturalized: Costa Rica, El Salvador, Guatemala, Nicaragua, West Indies, Suriname, Venezuela, U.S. (HI) (USDA-ARS, 2011).
Geo-C2 (Tropical savanna)	y - low	N/A	Native: Cambodia, Laos, Myanmar, Thailand, Vietnam; Naturalized: Costa Rica, El Salvador, Nicaragua, West Indies, Venezuela, U.S. (HI) (USDA-ARS, 2011).
Geo-C3 (Steppe)	y - negl	N/A	Greece, Spain, Mexico, U.S. (CA, AZ, NM, TX) (GBIF, 2011).
Geo-C4 (Desert)	y - low	N/A	U.S. (CA, AZ, NV, NM) (GBIF, 2011).
Geo-C5 (Mediterranean)	y - negl	N/A	Pakistan, Israel, Greece, Spain, Portugal, U.S. (CA, AZ) (GBIF, 2011).
Geo-C6 (Humid subtropical)	y - negl	N/A	Japan, U.S. (TX, AR, LA, MS, FL, AL, GA, TN, KY, MO, IL, WV, VA, NC, SC, MD) (GBIF, 2011);

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
			Uruguay (USDA-ARS, 2011).
Geo-C7 (Marine west coast)	y - negl	N/A	China, France, Spain (GBIF, 2011).
Geo-C8 (Humid cont. warm sum.)	y - low	N/A	Pakistan (GBIF, 2011).
Geo-C9 (Humid cont. cool sum.)	y - low	N/A	Spain, U.S. (WV, NM) (GBIF, 2011); Ukraine, Switzerland (USDA-ARS, 2011).
Geo-C10 (Subarctic)	n - mod	N/A	Listed as being in Switzerland (USDA-ARS, 2011), but no indication of where—subarctic temperatures may be too low for this tropical species.
Geo-C11 (Tundra)	n - mod	N/A	Listed as being in Switzerland (USDA-ARS, 2011), but no indication of where—subarctic temperatures may be too low for this tropical species.
Geo-C12 (Icecap)	n - negl	N/A	No evidence.
10-inch precipitation bands			
Geo-R1 (0-10")	y - low	N/A	U.S. (CA, NV, AZ, NM) (GBIF, 2011).
Geo-R2 (10-20")	y - negl	N/A	Israel, Spain, U.S. (CA, AZ, UT, NM, TX) (GBIF, 2011).
Geo-R3 (20-30")	y - negl	N/A	Pakistan, Israel, Greece, France, Spain, Portugal, Mexico, U.S. (CA, TX, KS) (GBIF, 2011).
Geo-R4 (30-40")	y - negl	N/A	China, Pakistan, Greece, France, Spain, Portugal, U.S. (CA, TX, KS, MO, IL) (GBIF, 2011).
Geo-R5 (40-50")	y - negl	N/A	China, France, Spain, Portugal, U.S. (CA, MO, KS, AR, KY, WV, VA, MD, NC, SC, GA) (GBIF, 2011); Myanmar, Thailand, Venezuela, Uruguay, and others (USDA-ARS, 2011).
Geo-R6 (50-60")	y - negl	N/A	China, Spain, Portugal, U.S. (LA, MS, AR, AL, TN, KY, GA, FL, NC, SC) (GBIF, 2011); Cambodia, Laos, Myanmar, Thailand, Vietnam, Nicaragua, Venezuela, Uruguay, and others (USDA-ARS, 2011).
Geo-R7 (60-70")	y - negl	N/A	Japan, U.S. (LA) (GBIF, 2011); Native: Cambodia, Laos, Myanmar, Thailand, Vietnam, Indonesia, Malaysia; Naturalized: El Salvador, Nicaragua, West Indies, Venezuela, and others (USDA-ARS, 2011).
Geo-R8 (70-80")	y - low	N/A	El Salvador, Nicaragua, West Indies, Venezuela, Uruguay (USDA-ARS, 2011).
Geo-R9 (80-90")	y - low	N/A	Cambodia, Myanmar, Vietnam, El Salvador, Nicaragua, Suriname, Venezuela, Uruguay (USDA-ARS, 2011).
Geo-R10 (90-100")	y - low	N/A	Cambodia, Myanmar, Indonesia, Malaysia, Nicaragua, Suriname, Venezuela (USDA-ARS, 2011).
Geo-R11 (100"+)	y - low	N/A	Cambodia, Myanmar, Indonesia, Malaysia, Costa Rica, Guatemala, Nicaragua, Suriname (USDA-ARS, 2011).
Entry Potential			
Ent-1 (Already here)	y - negl	1	Cultivated as an ornamental in Canada (CFIA, 2009). Widely naturalized in the United States (Kartesz, 2011; NRCS, 2011).
Ent-2 (Proposed for entry)		N/A	

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
Ent-3 (Human value & cultivation/trade status)		N/A	
Ent-4 (Entry as a Contaminant)			
Ent-4a (In MX, CA, Central Amer., Carib., or China)		N/A	
Ent-4b (Propagative material)		N/A	
Ent-4c (Seeds)		N/A	
Ent-4d (Ballast water)		N/A	
Ent-4e (Aquaria)		N/A	
Ent-4f (Landscape products)		N/A	
Ent-4g (Container, packing, trade goods)		N/A	
Ent-4h (Commodities for consumption)		N/A	
Ent-4i (Other pathway)		N/A	
Ent-5 (Natural dispersal)		N/A	